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Yamanaka et al.

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(54) **IMAGE-CAPTURING APPARATUS, CONTROL METHOD, AND PROGRAM**

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(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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H04N 5/262 (2006.01)
B60R 1/26 (2022.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 5/2628*** (2013.01); ***B60R 1/26*** (2022.01); ***H04N 7/18*** (2013.01); ***H04N 23/80*** (2023.01); *B60R 2300/30* (2013.01)

(58) **Field of Classification Search**
CPC H04N 5/2628; H04N 5/2322; H04N 7/18; B60R 1/00; B60R 2300/30
See application file for complete search history.

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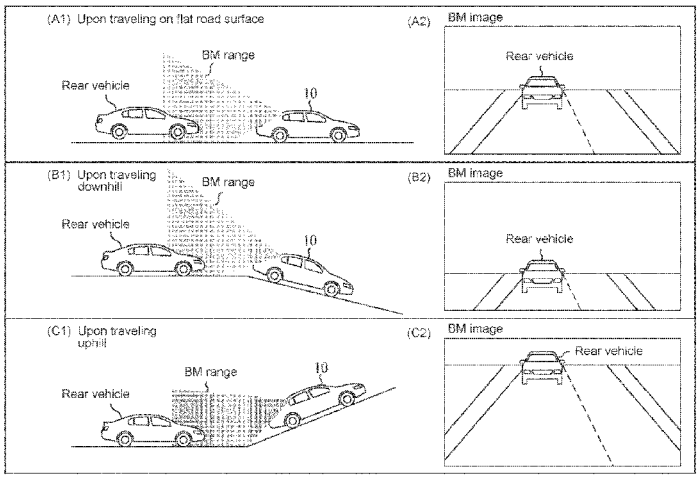
(57) **ABSTRACT**

An image-capturing apparatus, a control method, and a program that make it possible to easily provide an image suitable for the operation of a vehicle. The controller controls reading of an image from an image sensor that captures the image, on the basis of vehicle information acquired by a vehicle, the image being displayed on a display section of the vehicle. Embodiments may be applicable to a viewing system that displays an image of a region behind a vehicle.

16 Claims, 26 Drawing Sheets



(51) **Int. Cl.**
H04N 7/18 (2006.01)
H04N 23/80 (2023.01)

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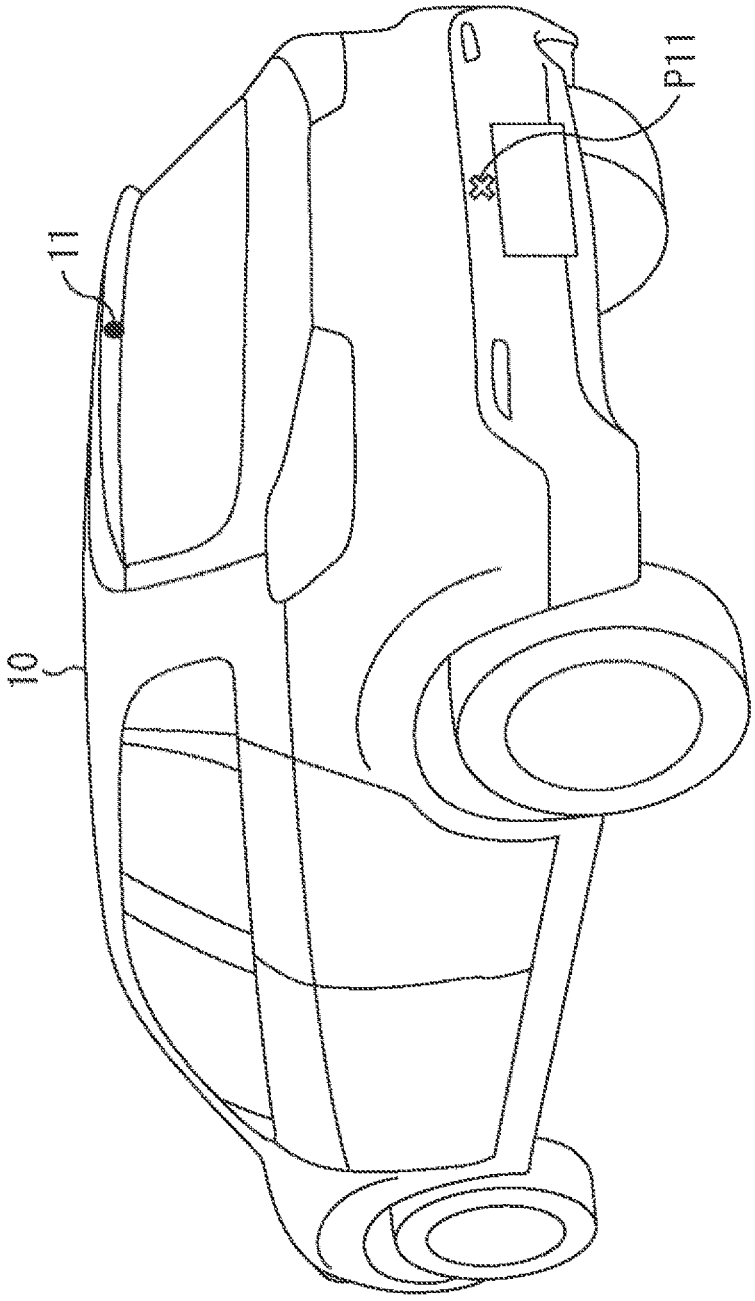


FIG.1

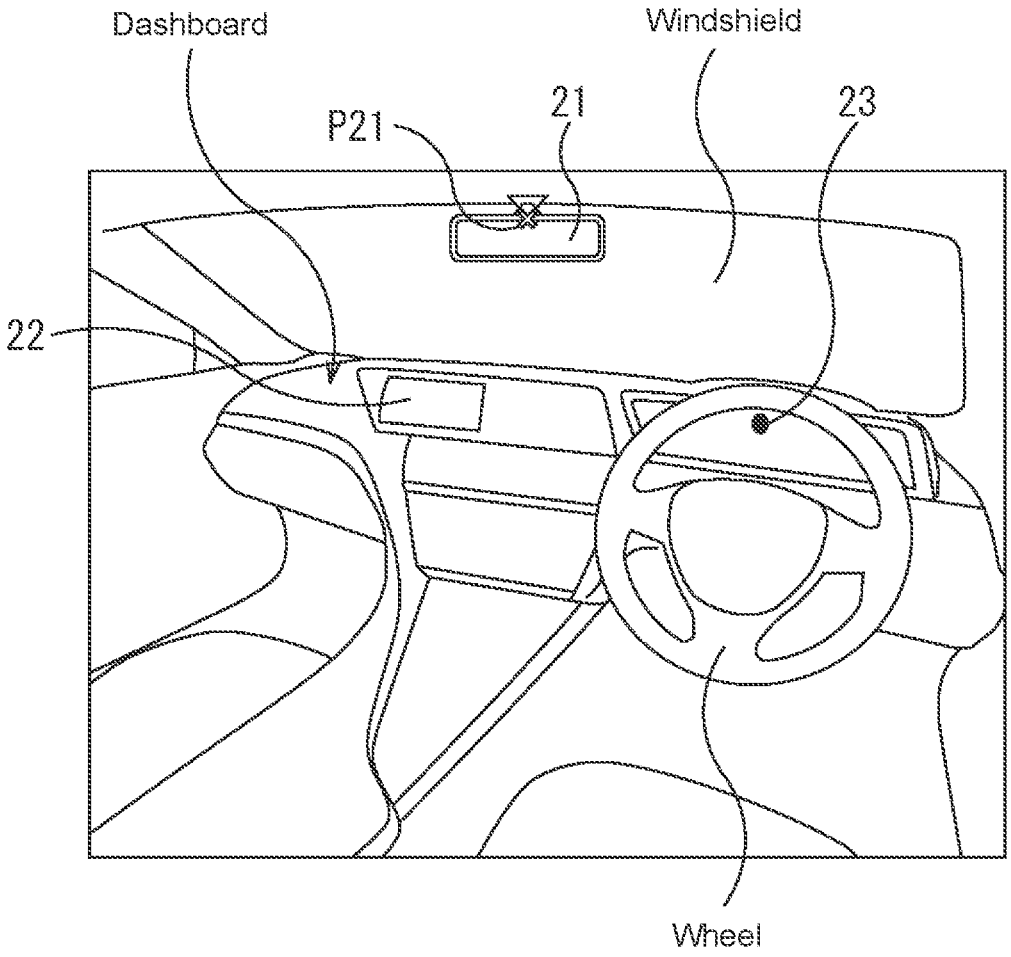


FIG.2

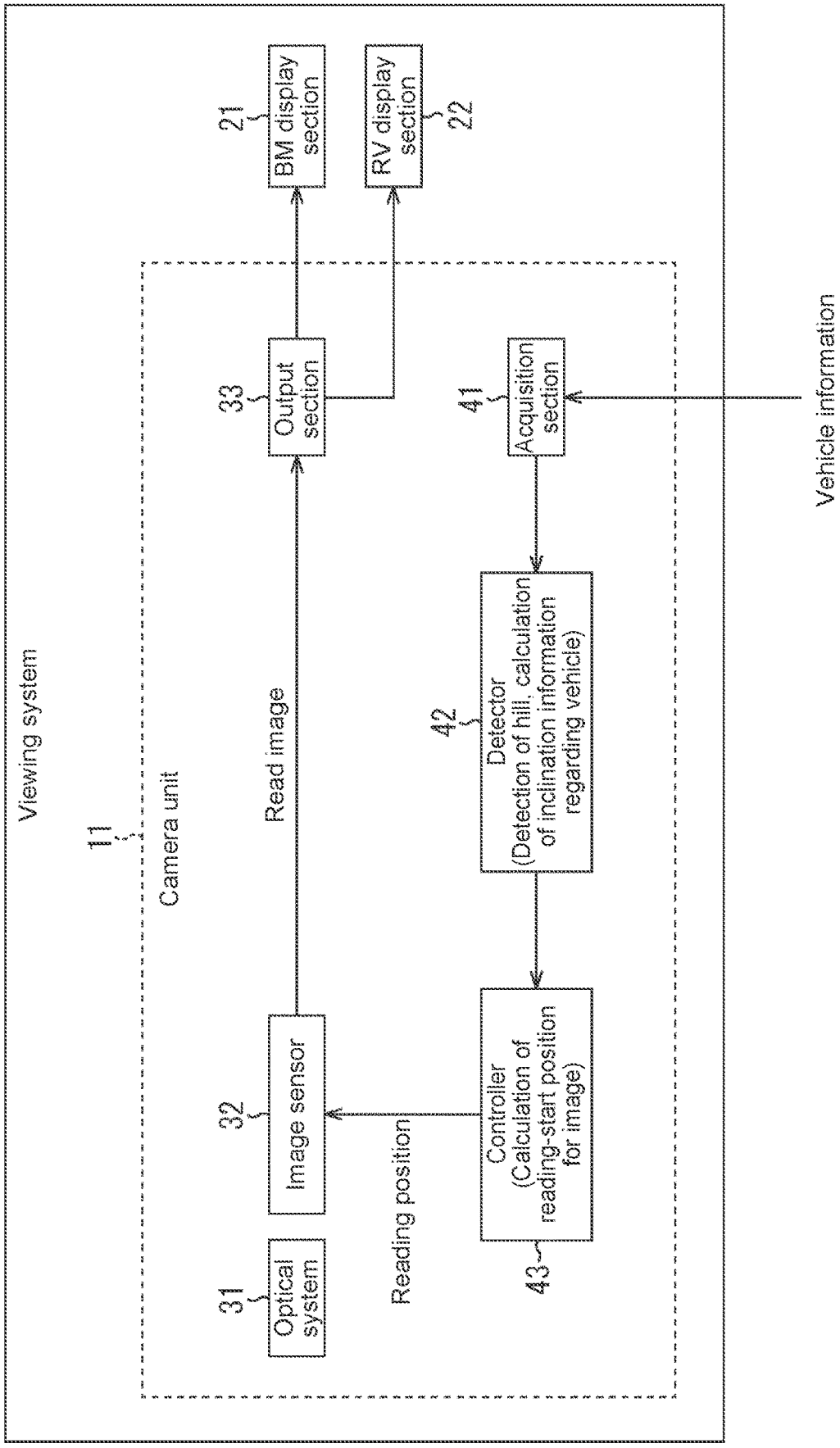

Viewing system
11
Camera unit
21
BM display section
22
RV display section
33
Output section
41
Acquisition section
Vehicle information
Read image
42
Detector (Detection of hill, calculation of inclination information regarding vehicle)
32
Image sensor
Controller (Calculation of reading-start position for image)
Reading position
31
Optical system
43

FIG. 3

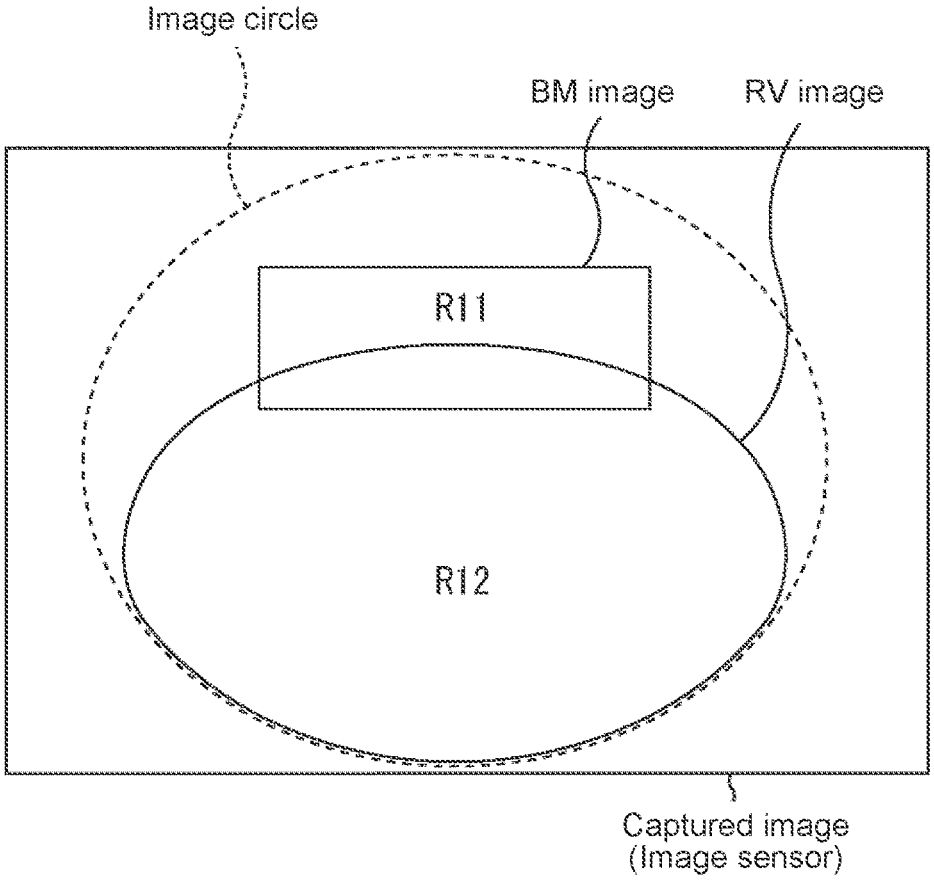


Image circle
BM image
RV image
R11
R12
Captured image
(Image sensor)

FIG.4

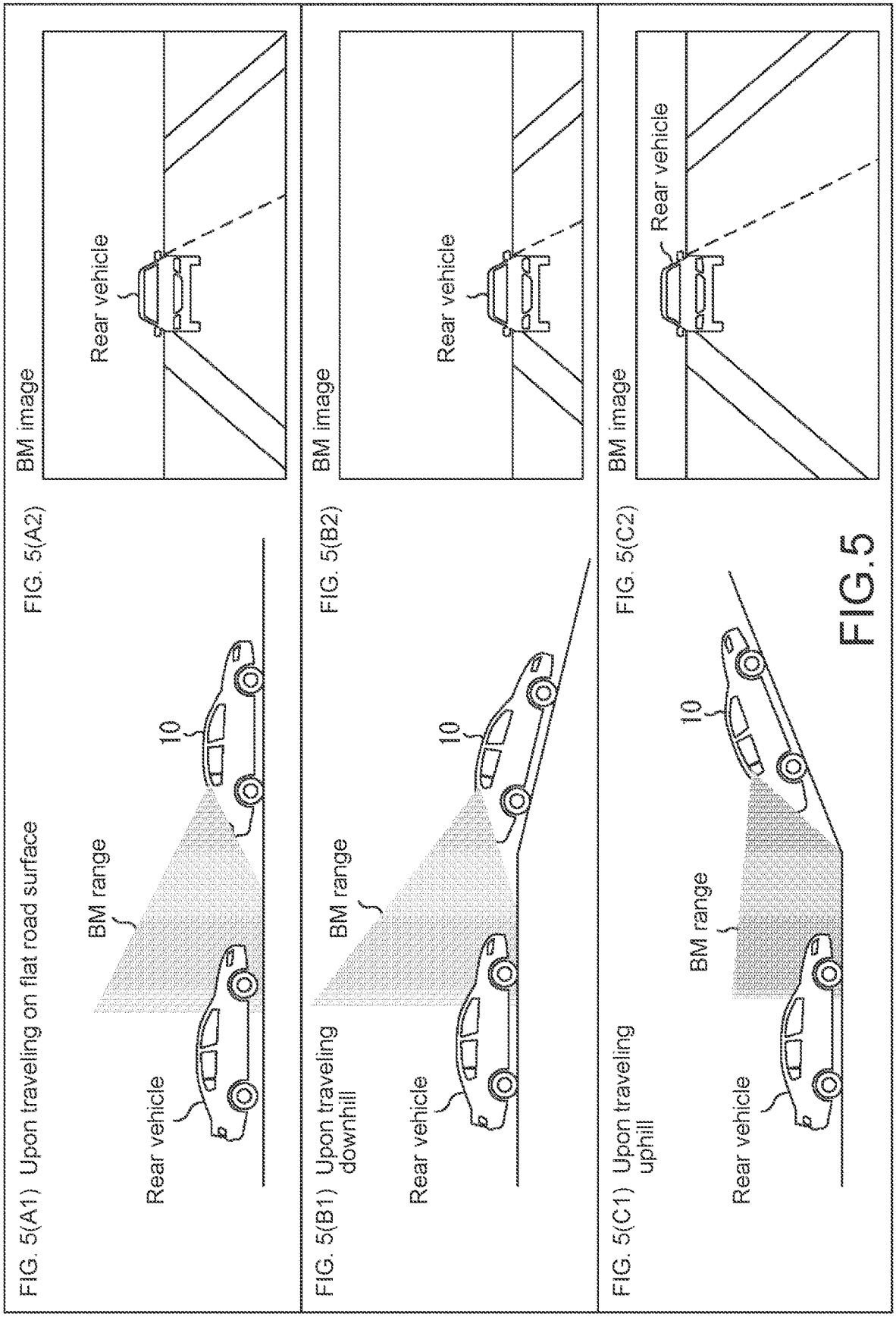


FIG. 5(A1) Upon traveling on flat road surface
FIG. 5(A2)
BM image
Rear vehicle
10
BM range
Rear vehicle
FIG. 5(B1) Upon traveling downhill
FIG. 5(B2)
BM image
Rear vehicle
10
BM range
Rear vehicle
FIG. 5(C1) Upon traveling uphill
FIG. 5(C2)
BM image
Rear vehicle
10
BM range
Rear vehicle

FIG. 5

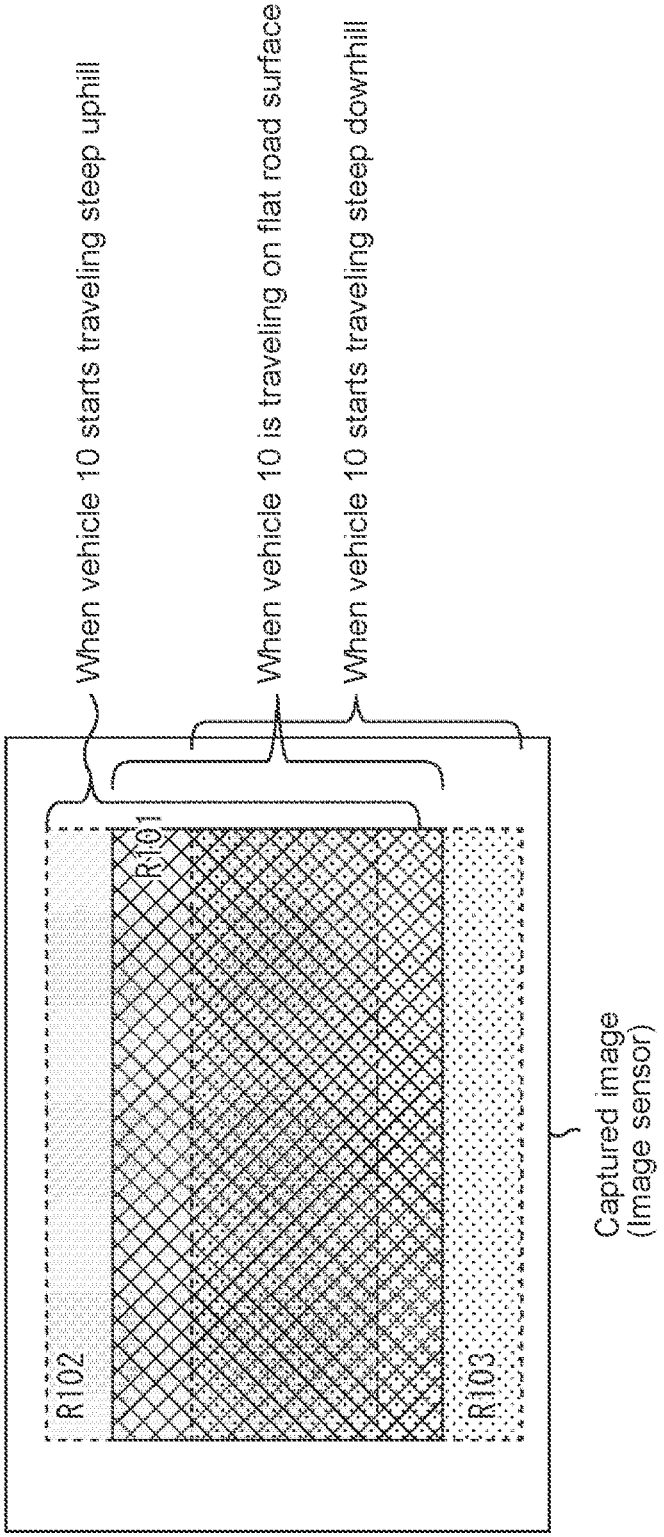

When vehicle 10 starts traveling steep uphill
When vehicle 10 is traveling on flat road surface
When vehicle 10 starts traveling steep downhill
R101
R102
R103
Captured image
(Image sensor)

FIG.6

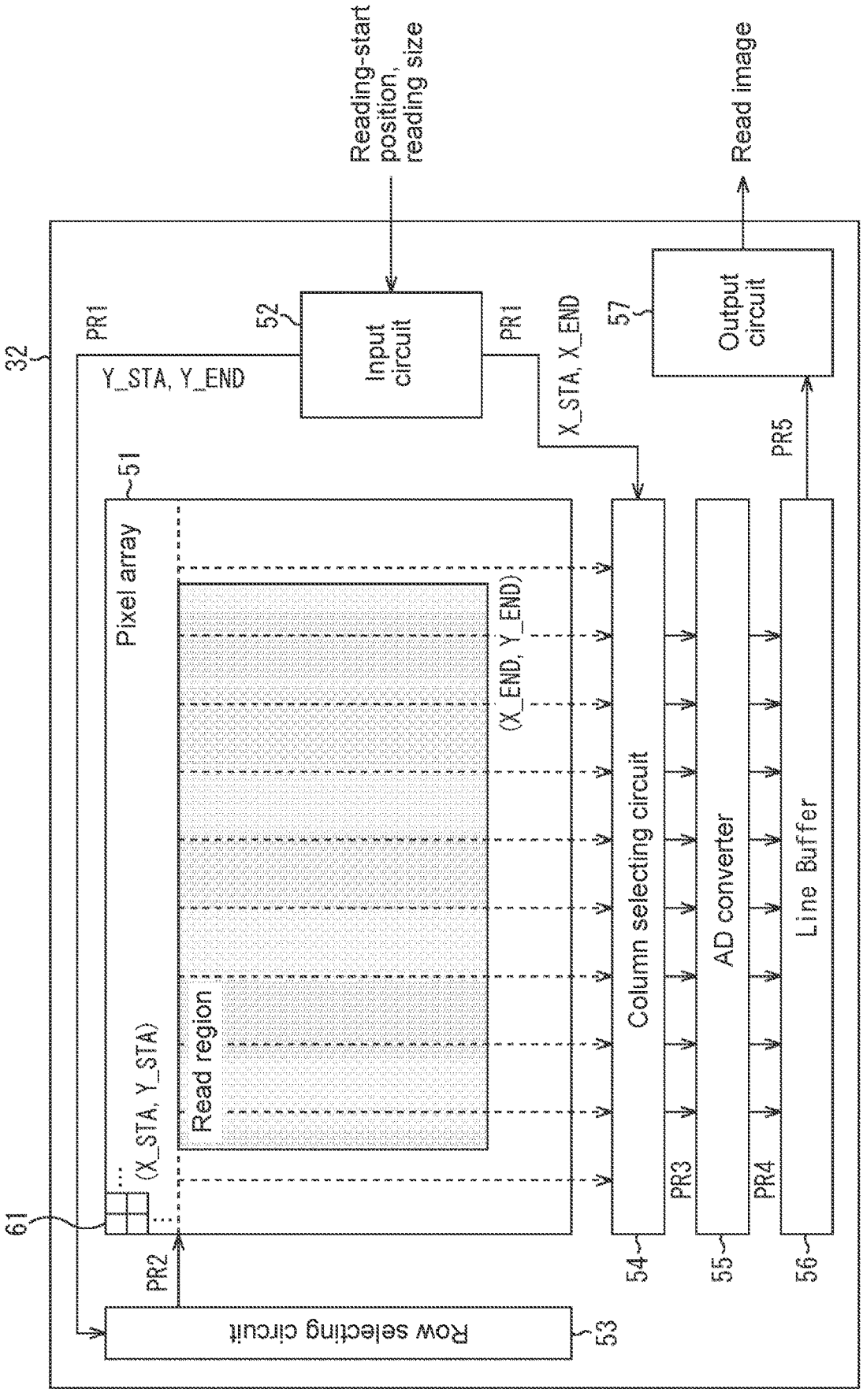

Reading-start position, reading size
Read image
32
PR1
Y_STA, Y_END
52
Input circuit
PR1
X_STA, X_END
57
Output circuit
PR5
51
Pixel array
(X_END, Y_END)
Read region
(X_STA, Y_STA)
61
PR2
Row selecting circuit
53
Column selecting circuit
54
PR3
AD converter
55
PR4
Line Buffer
56

FIG.7

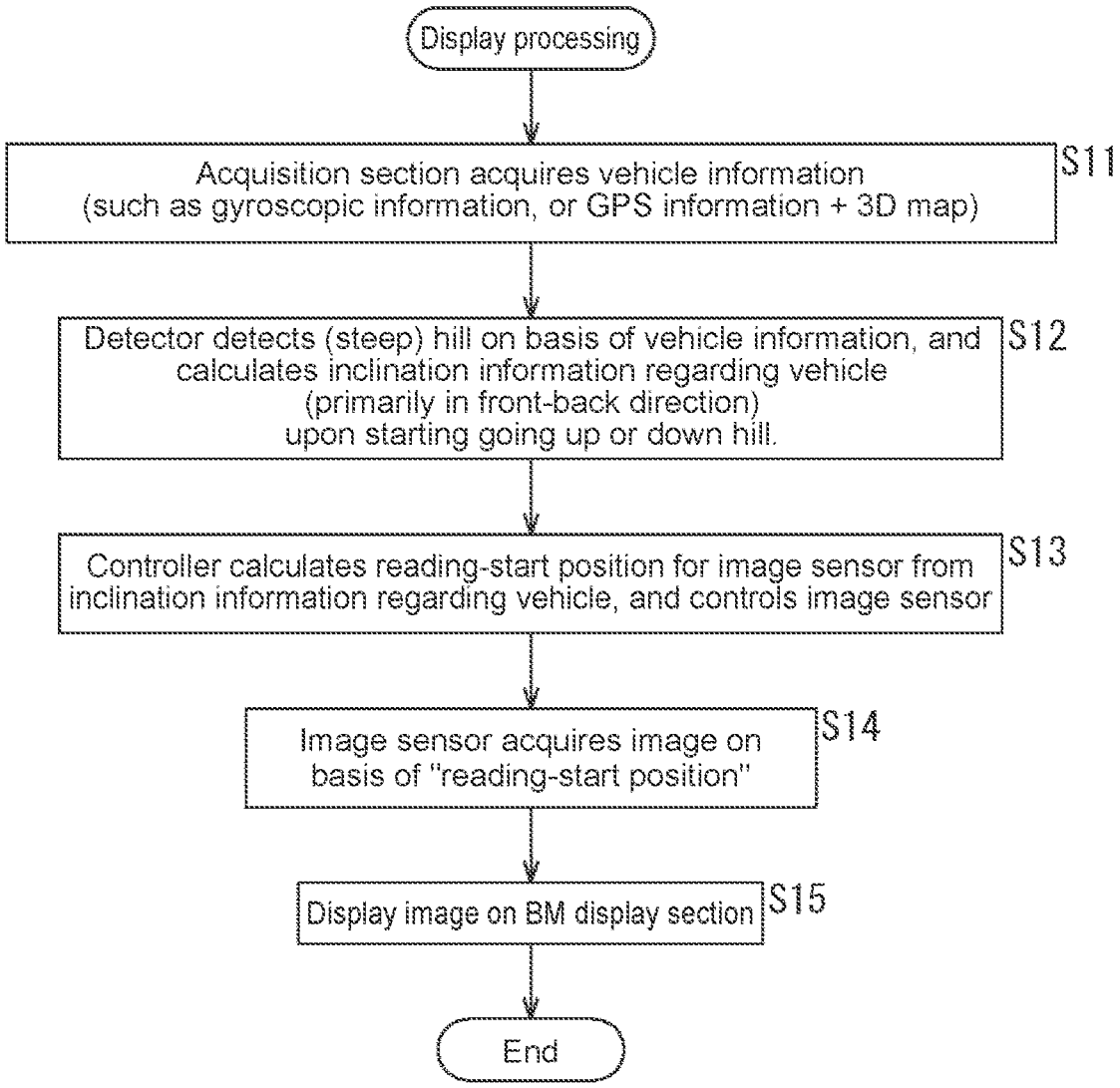

Display processing
Acquisition section acquires vehicle information (such as gyroscopic information, or GPS information + 3D map)
S11
Detector detects (steep) hill on basis of vehicle information, and calculates inclination information regarding vehicle (primarily in front-back direction) upon starting going up or down hill.
S12
Controller calculates reading-start position for image sensor from inclination information regarding vehicle, and controls image sensor
S13
Image sensor acquires image on basis of "reading-start position"
S14
Display image on BM display section
S15
End

FIG.8

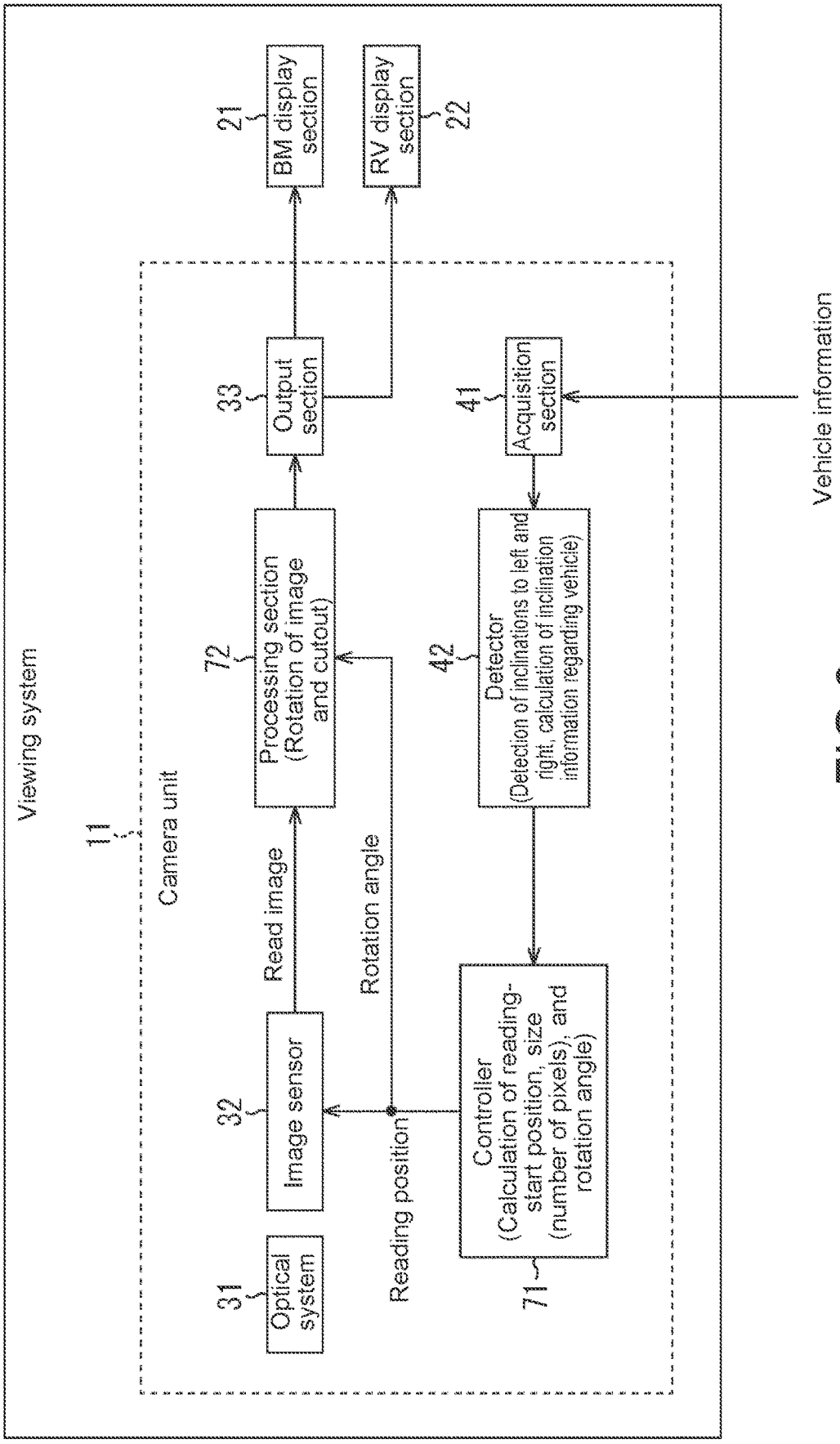

Viewing system
11
Camera unit
21
BM display section
22
RV display section
33
Output section
41
Acquisition section
Vehicle information
72
Processing section (Rotation of image and cutout)
42
Detector (Detection of inclinations to left and right, calculation of inclination information regarding vehicle)
Read image
Rotation angle
32
Image sensor
Controller (Calculation of reading-start position, size (number of pixels), and rotation angle)
Reading position
31
Optical system
71

FIG. 9

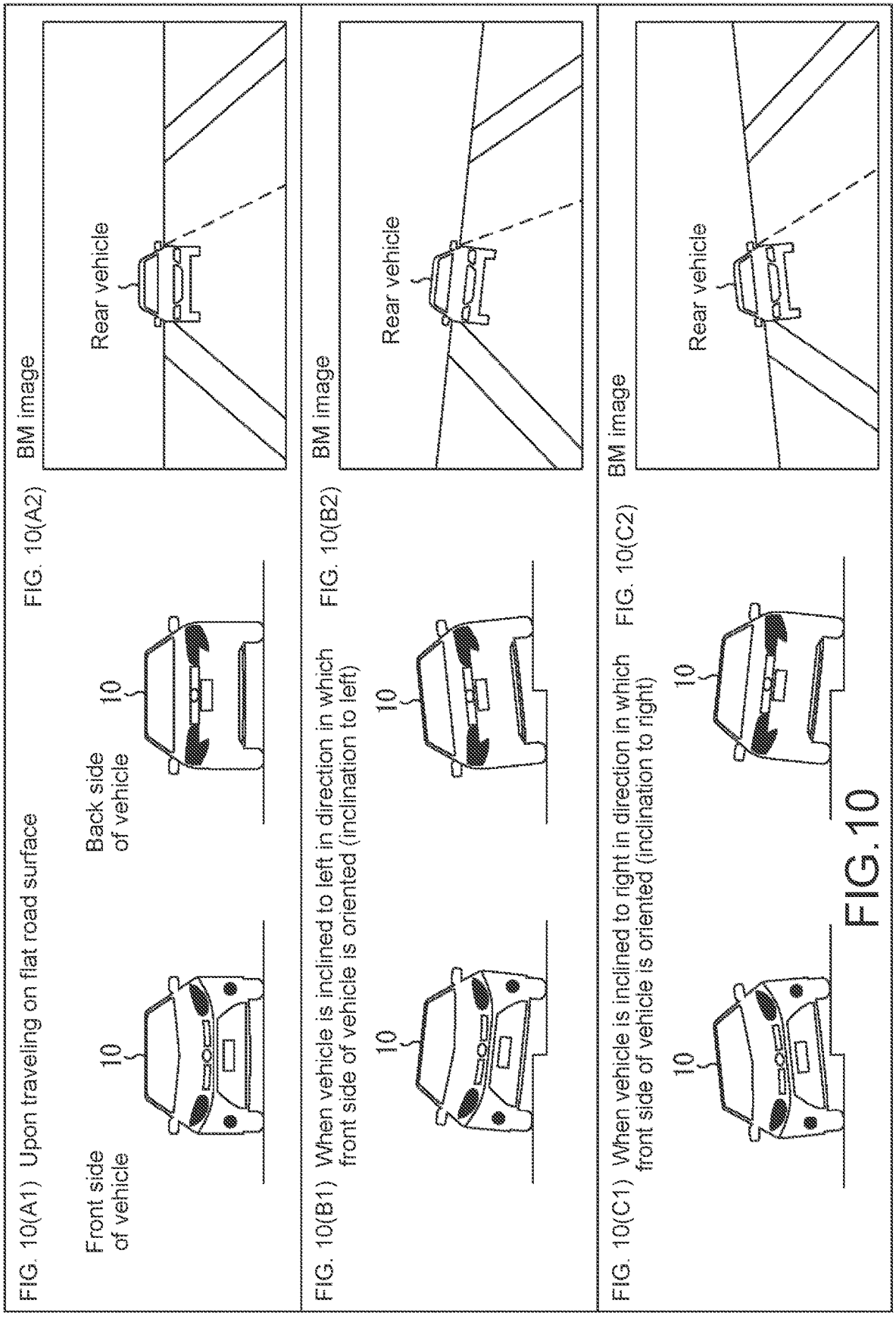


FIG. 10(A1) Upon traveling on flat road surface
FIG. 10(A2)
Front side of vehicle
Back side of vehicle
10
BM image
Rear vehicle
FIG. 10(B1) When vehicle is inclined to left in direction in which front side of vehicle is oriented (inclination to left)
FIG. 10(B2)
10
BM image
Rear vehicle
FIG. 10(C1) When vehicle is inclined to right in direction in which front side of vehicle is oriented (inclination to right)
FIG. 10(C2)
10
BM image
Rear vehicle

FIG.10

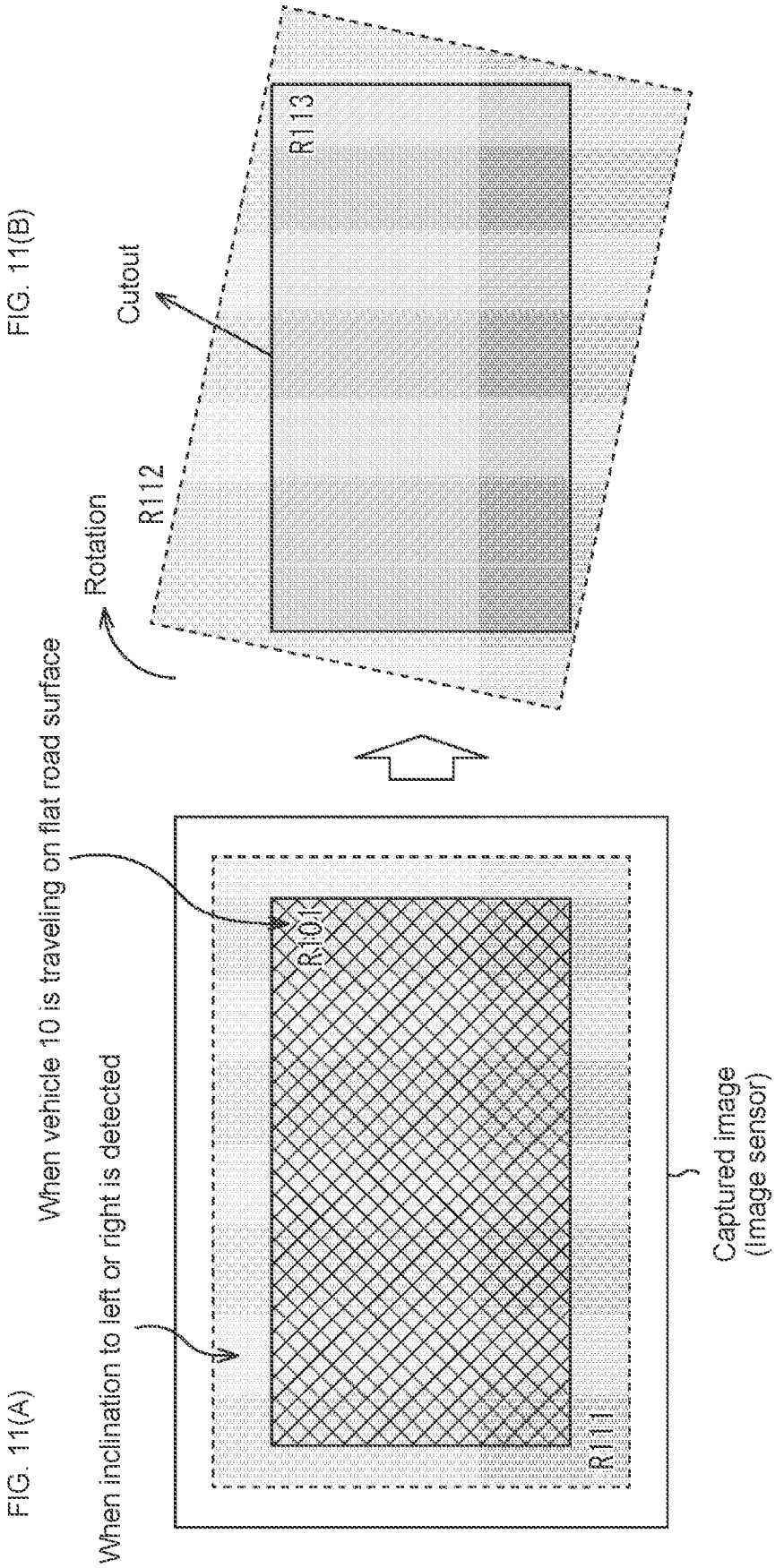


FIG. 11(A)
When vehicle 10 is traveling on flat road surface
When inclination to left or right is detected
R101
R111
Captured image
(Image sensor)
FIG. 11(B)
Rotation
R112
Cutout
R113

FIG. 12(A)

FIG. 12(B)

FIG. 12(C)

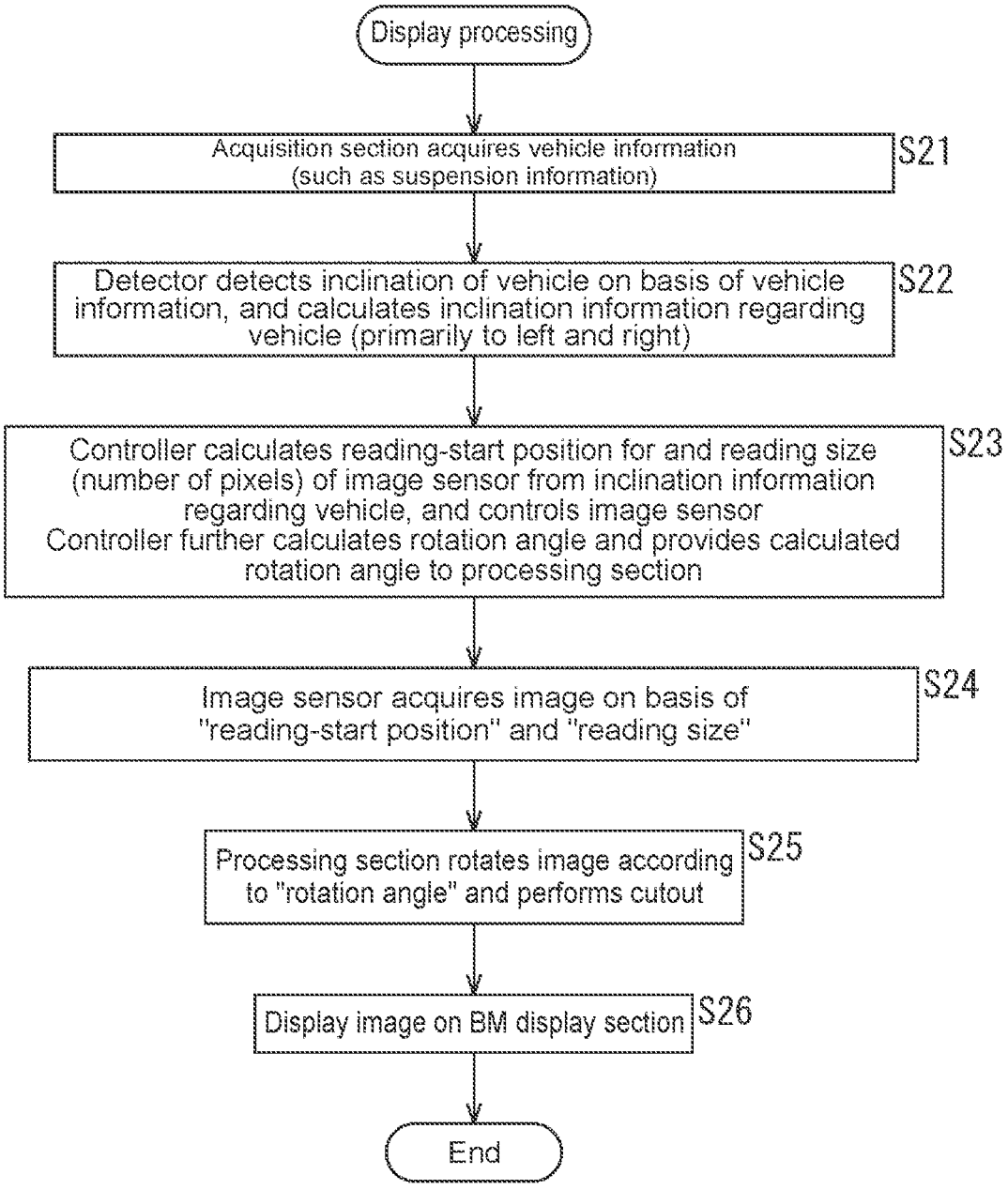

Display processing
Acquisition section acquires vehicle information (such as suspension information)
S21
Detector detects inclination of vehicle on basis of vehicle information, and calculates inclination information regarding vehicle (primarily to left and right)
S22
Controller calculates reading-start position for and reading size (number of pixels) of image sensor from inclination information regarding vehicle, and controls image sensor
Controller further calculates rotation angle and provides calculated rotation angle to processing section
S23
Image sensor acquires image on basis of "reading-start position" and "reading size"
S24
Processing section rotates image according to "rotation angle" and performs cutout
S25
Display image on BM display section
S26
End

FIG.13

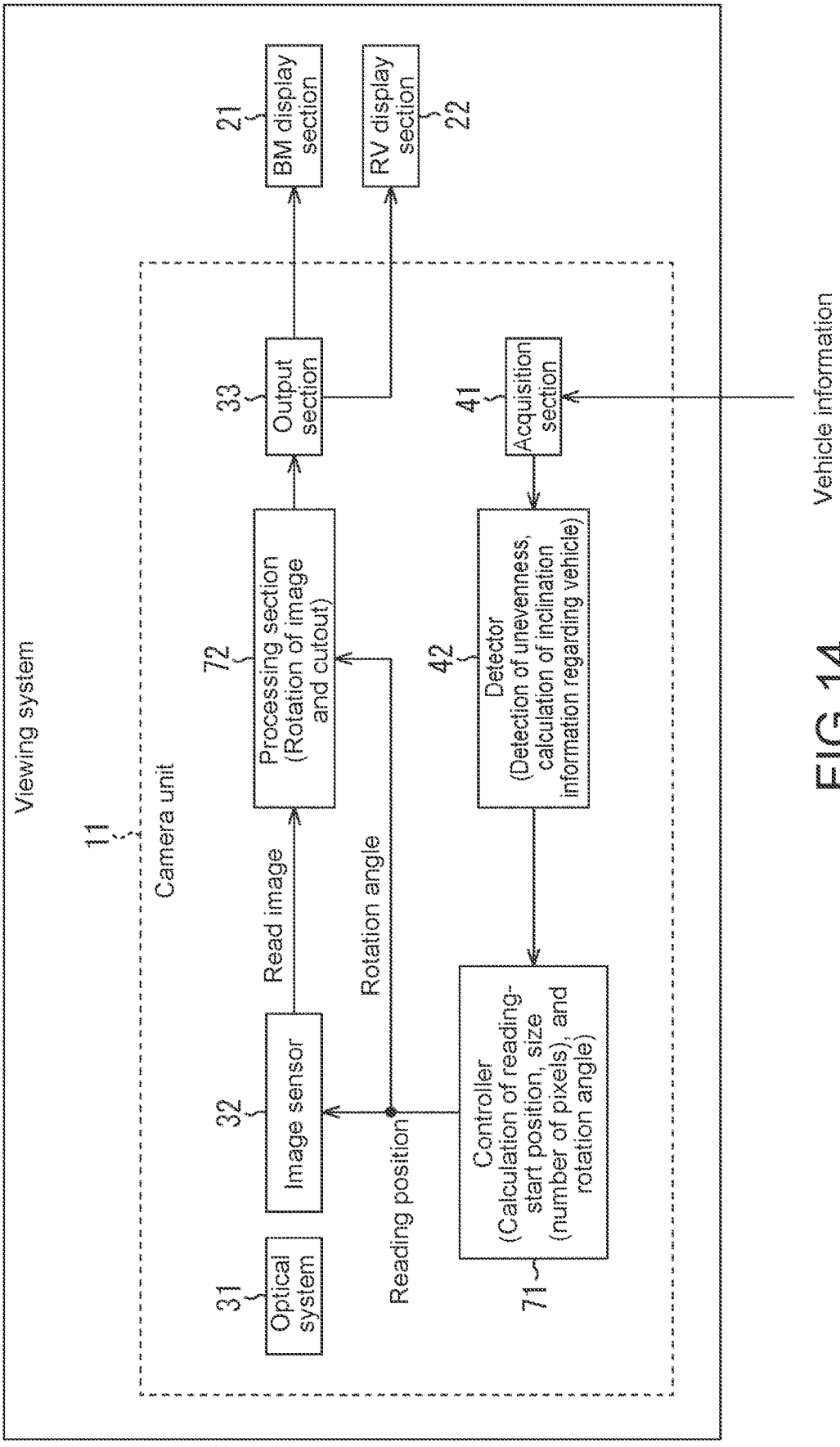

Viewing system
11
Camera unit
31
Optical system
32
Image sensor
Read image
72
Processing section (Rotation of image and cutout)
33
Output section
21
BM display section
22
RV display section
Reading position
Rotation angle
71
Controller (Calculation of reading-start position, size (number of pixels), and rotation angle)
42
Detector (Detection of unevenness, calculation of inclination information regarding vehicle)
41
Acquisition section
Vehicle information

FIG. 14

FIG. 15(A)

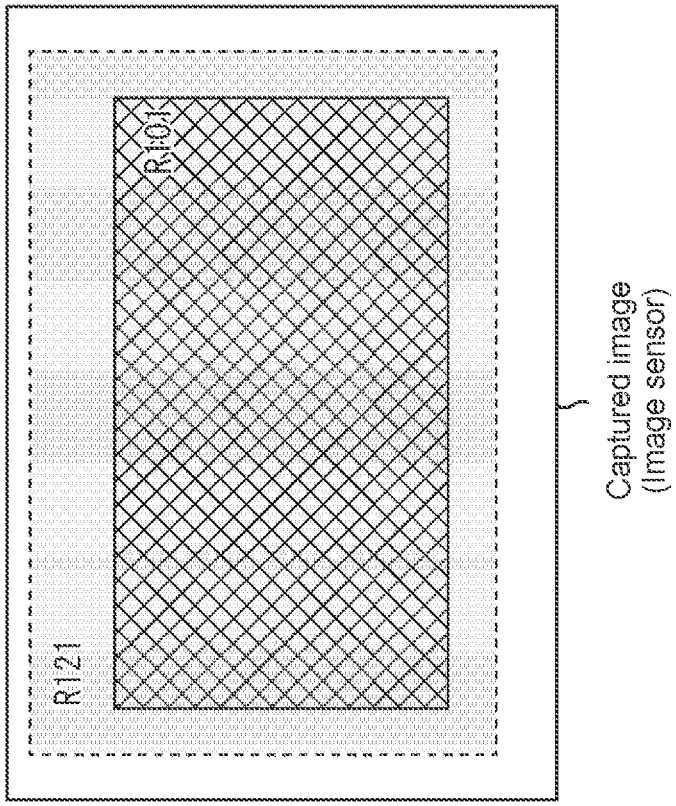
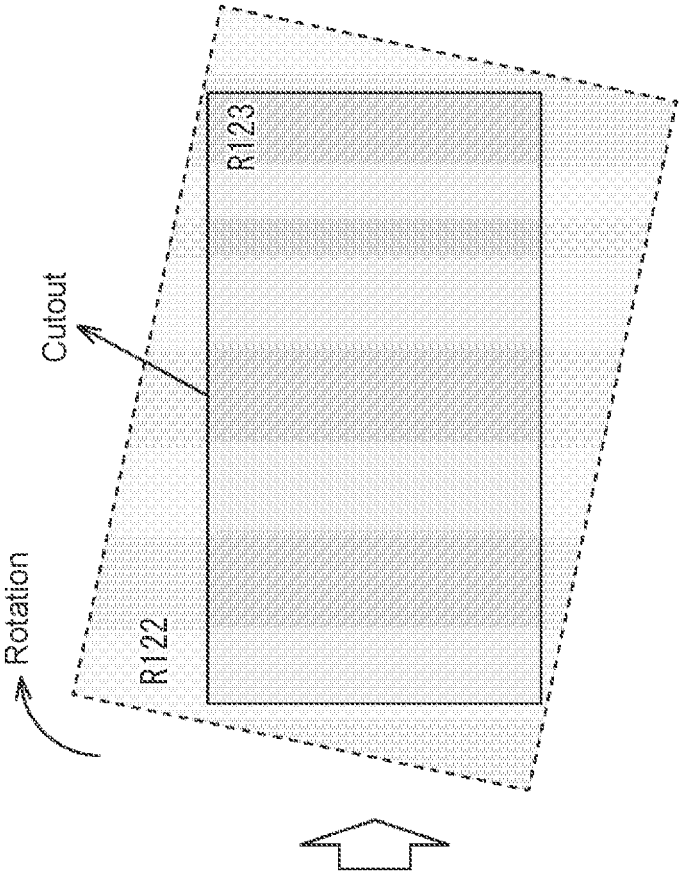


FIG. 15(B)



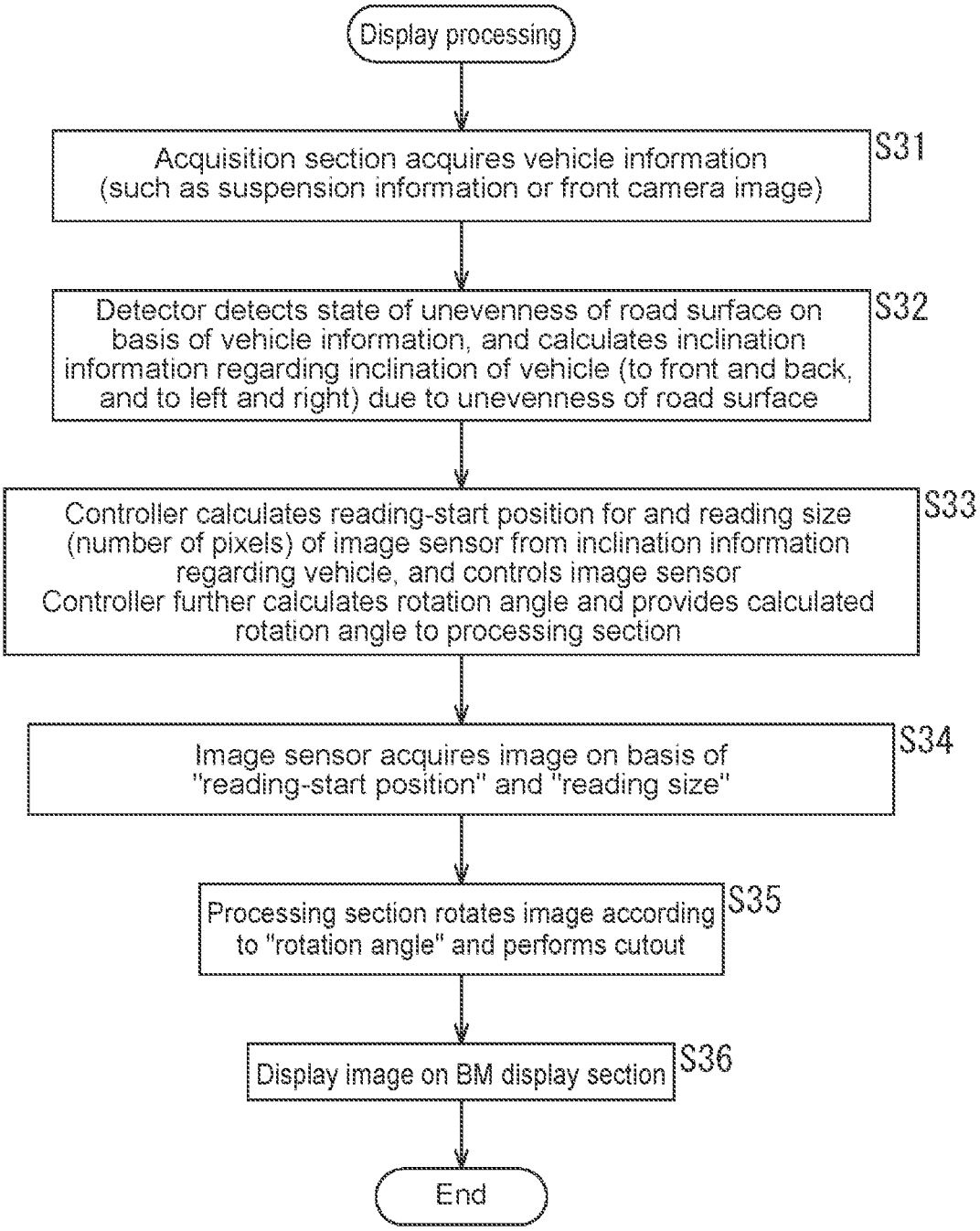

Display processing
Acquisition section acquires vehicle information (such as suspension information or front camera image)
S31
Detector detects state of unevenness of road surface on basis of vehicle information, and calculates inclination information regarding inclination of vehicle (to front and back, and to left and right) due to unevenness of road surface
S32
Controller calculates reading-start position for and reading size (number of pixels) of image sensor from inclination information regarding vehicle, and controls image sensor
Controller further calculates rotation angle and provides calculated rotation angle to processing section
S33
Image sensor acquires image on basis of "reading-start position" and "reading size"
S34
Processing section rotates image according to "rotation angle" and performs cutout
S35
Display image on BM display section
S36
End

FIG.16

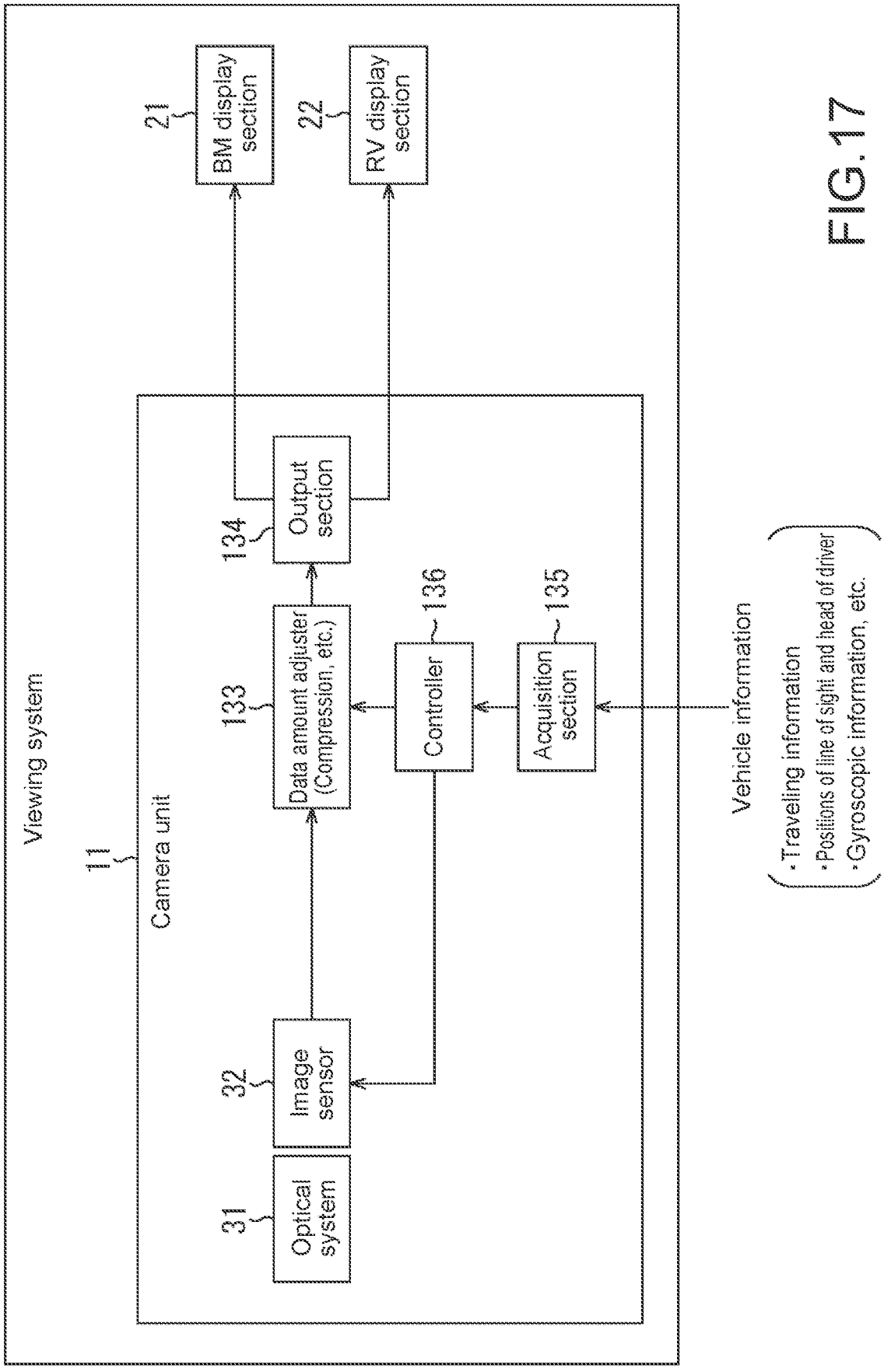

Viewing system
11
Camera unit
31
Optical system
32
Image sensor
133
Data amount adjuster (Compression, etc.)
134
Output section
136
Controller
135
Acquisition section
21
BM display section
22
RV display section
Vehicle information
• Traveling information
• Positions of line of sight and head of driver
• Gyroscopic information, etc.

FIG. 17

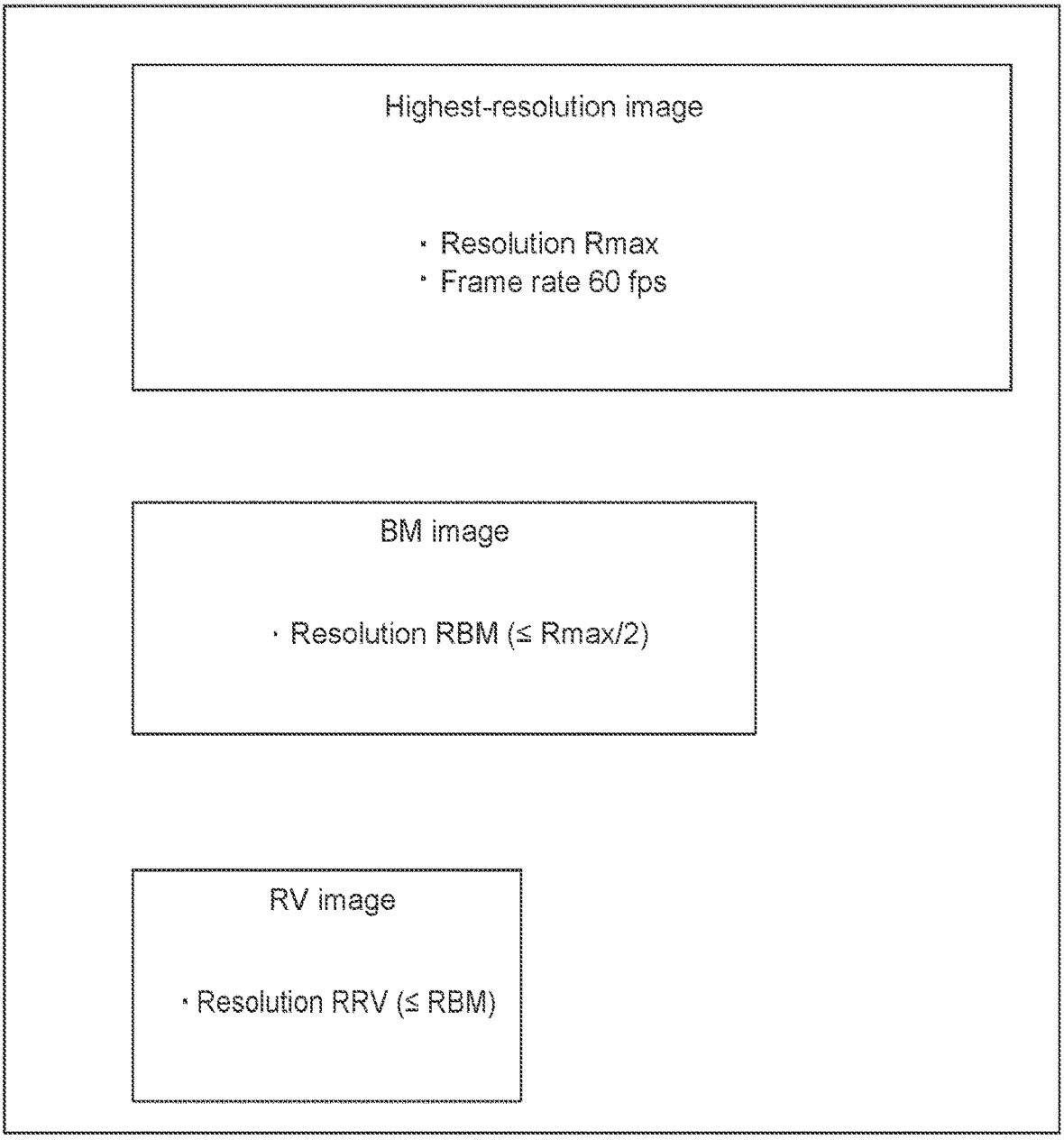

Highest-resolution image
• Resolution Rmax
• Frame rate 60 fps
BM image
• Resolution RBM (≤ Rmax/2)
RV image
• Resolution RRV (≤ RBM)

FIG.18

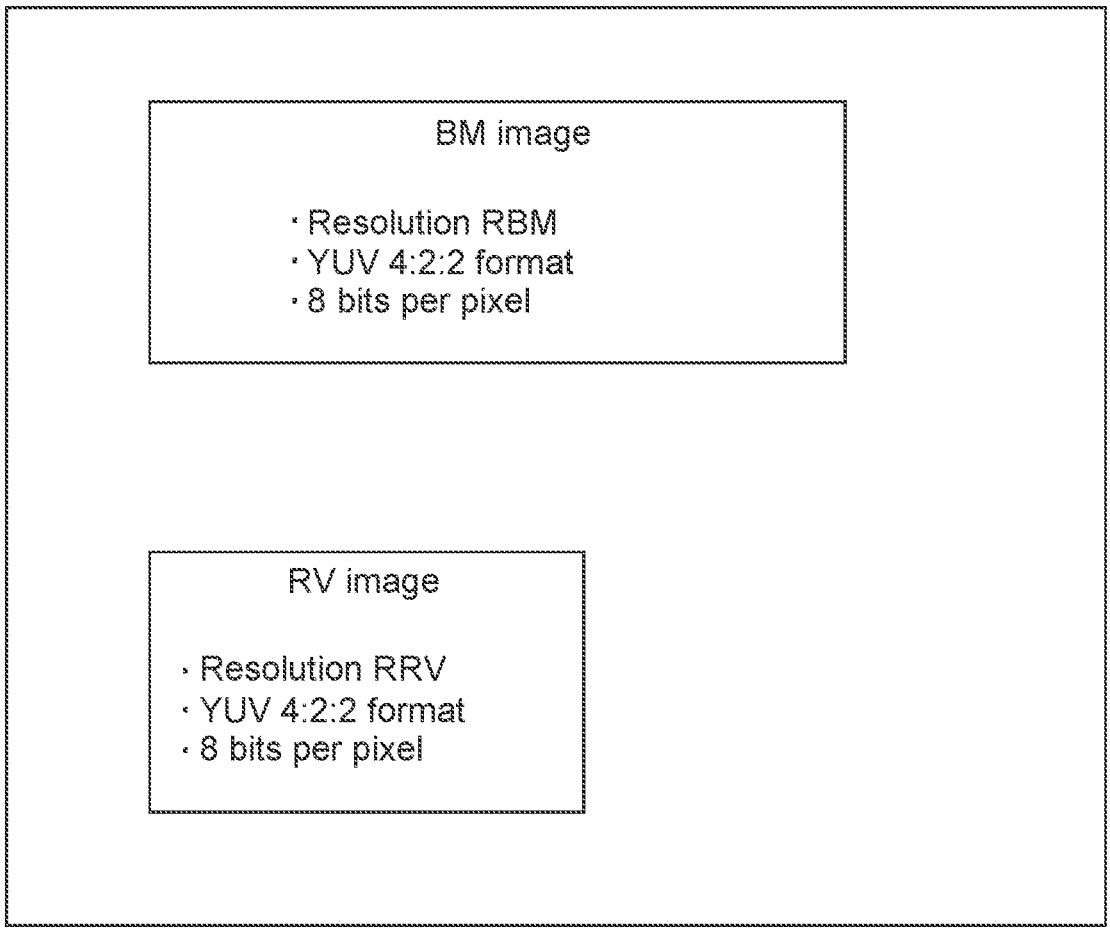

BM image
· Resolution RBM
· YUV 4:2:2 format
· 8 bits per pixel
RV image
· Resolution RRV
· YUV 4:2:2 format
· 8 bits per pixel

FIG.19

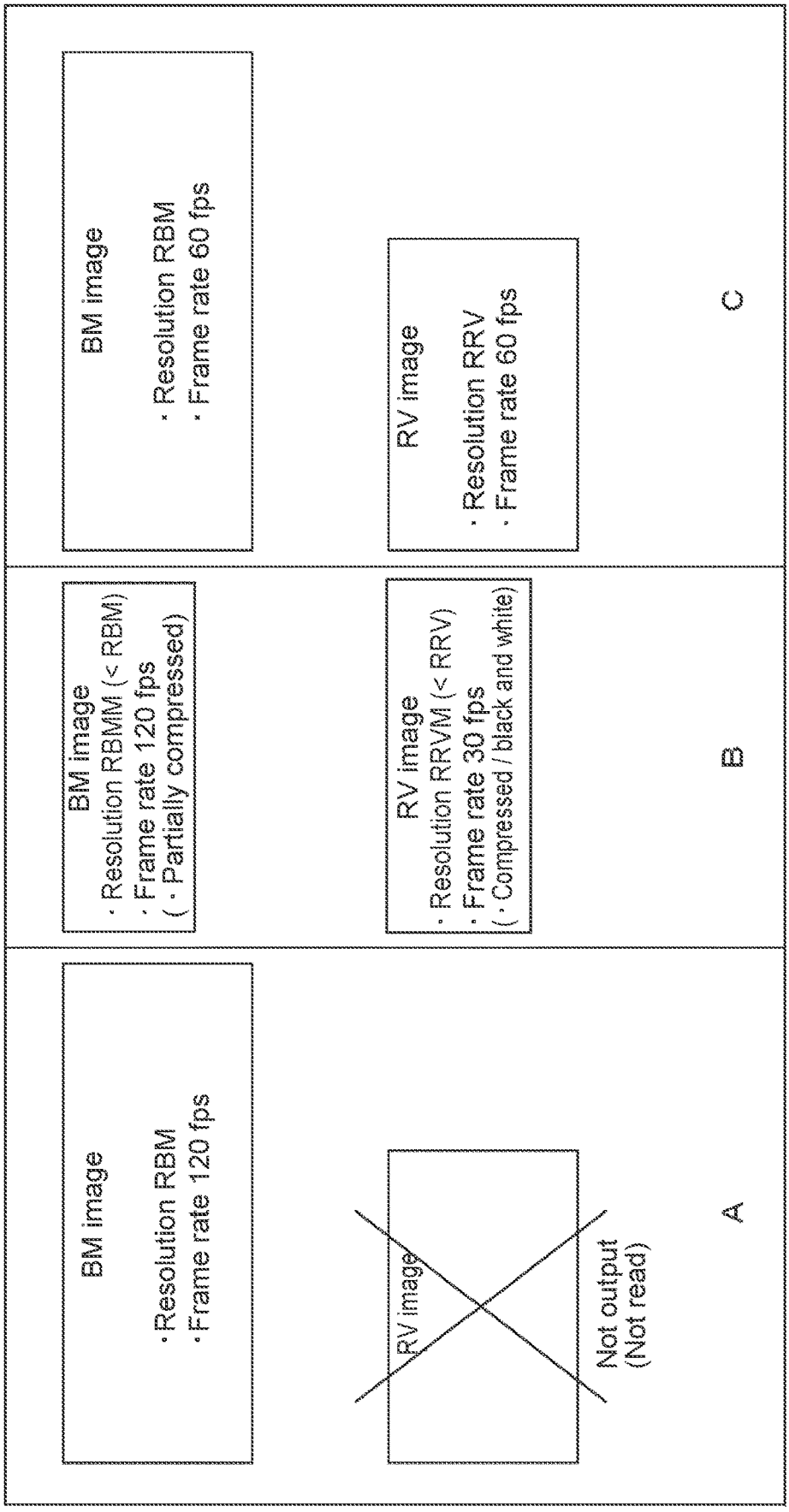

BM image
· Resolution RBM
· Frame rate 120 fps
RV image
Not output
(Not read)
A
BM image
· Resolution RBMM (< RBM)
· Frame rate 120 fps
(· Partially compressed)
RV image
· Resolution RRVM (< RRV)
· Frame rate 30 fps
(· Compressed / black and white)
B
BM image
· Resolution RBM
· Frame rate 60 fps
RV image
· Resolution RRV
· Frame rate 60 fps
C

FIG.20

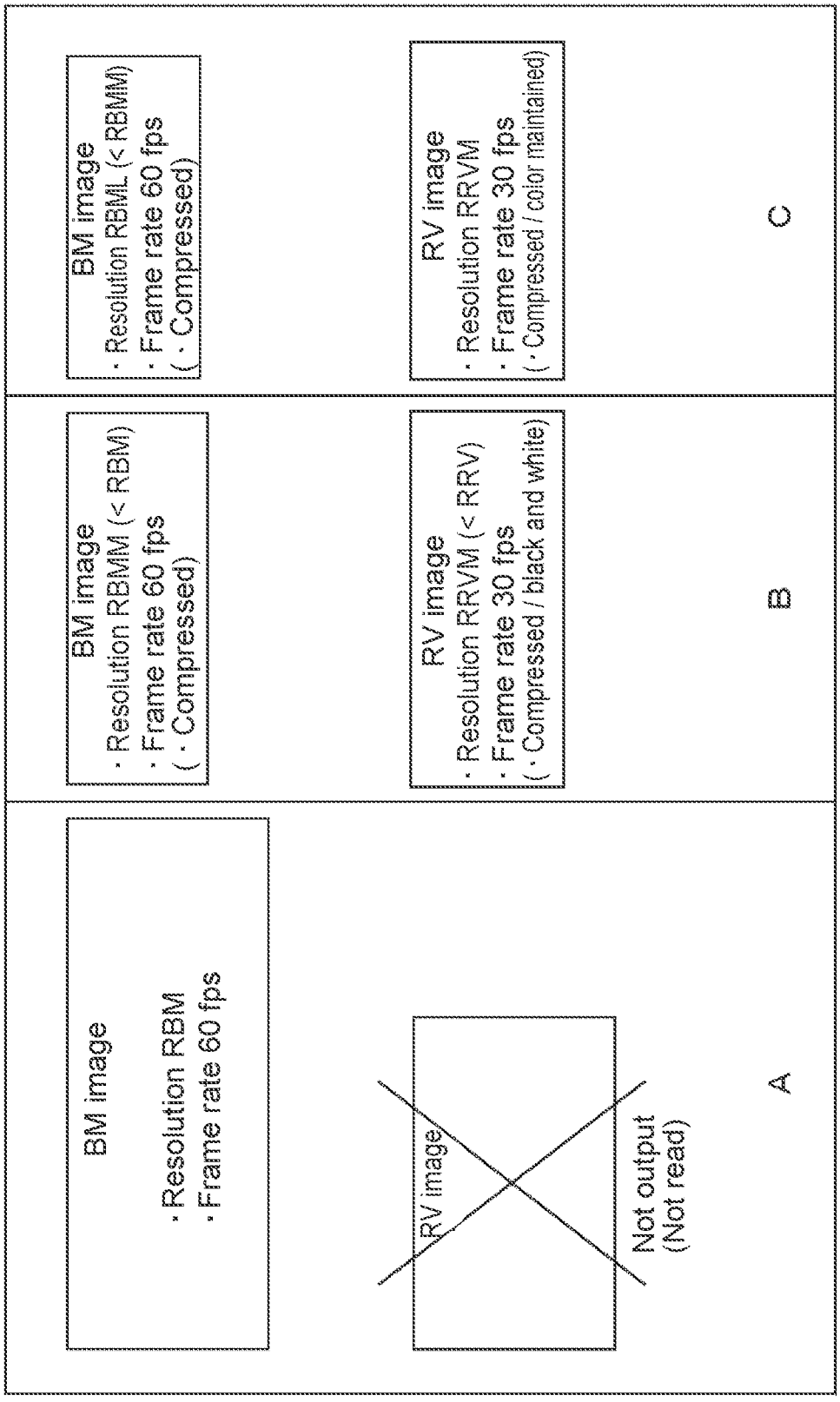

BM image
· Resolution RBM
· Frame rate 60 fps
RV image
Not output
(Not read)
A
BM image
· Resolution RBMM (< RBM)
· Frame rate 60 fps
(· Compressed)
RV image
· Resolution RRVM (< RRV)
· Frame rate 30 fps
(· Compressed / black and white)
B
BM image
· Resolution RBML (< RBMM)
· Frame rate 60 fps
(· Compressed)
RV image
· Resolution RRVM
· Frame rate 30 fps
(· Compressed / color maintained)
C

FIG.21

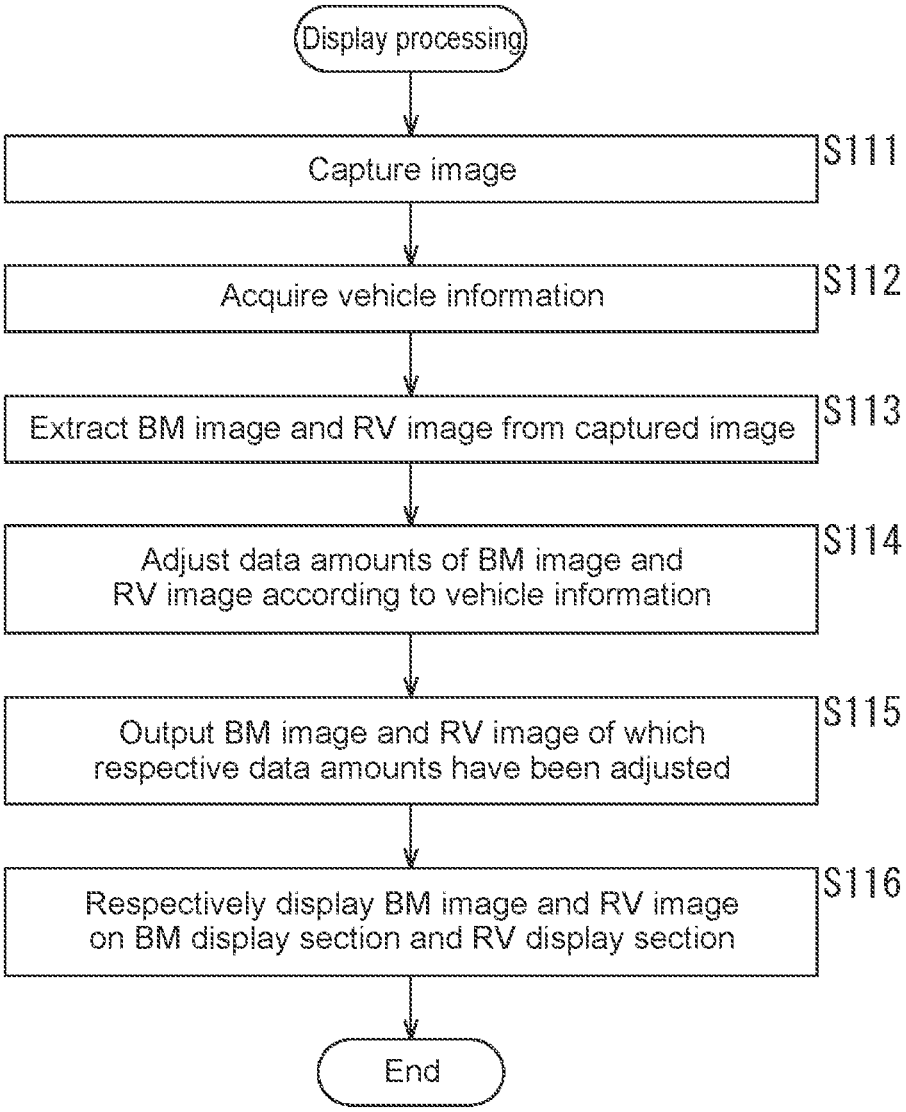

Display processing
Capture image
S111
Acquire vehicle information
S112
Extract BM image and RV image from captured image
S113
Adjust data amounts of BM image and RV image according to vehicle information
S114
Output BM image and RV image of which respective data amounts have been adjusted
S115
Respectively display BM image and RV image on BM display section and RV display section
S116
End

FIG.22

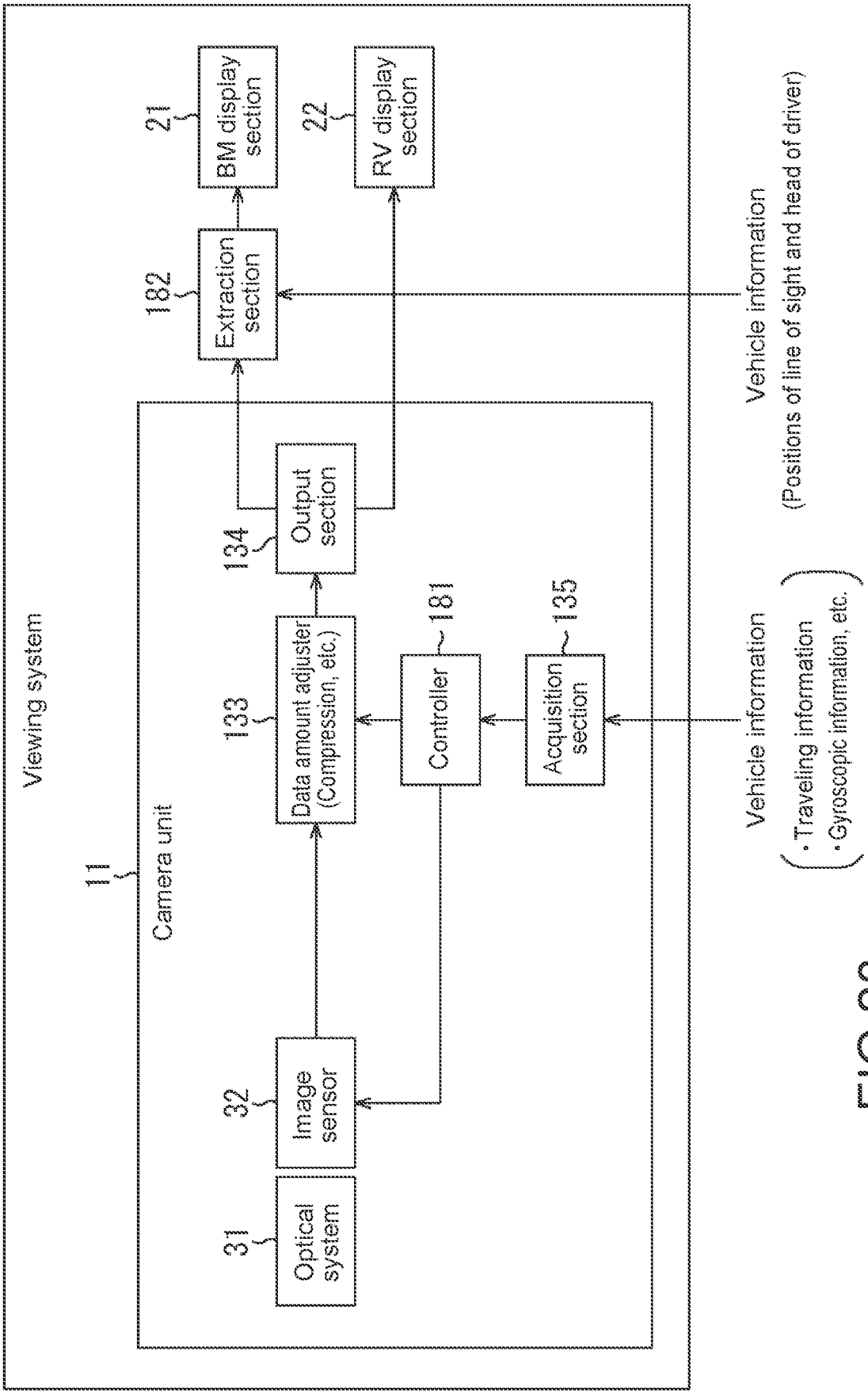

Viewing system
11
Camera unit
31
Optical system
32
Image sensor
133
Data amount adjuster (Compression, etc.)
134
Output section
181
Controller
135
Acquisition section
182
Extraction section
21
BM display section
22
RV display section
Vehicle information
(Positions of line of sight and head of driver)
Vehicle information
・Traveling information
・Gyroscopic information, etc.

FIG.23

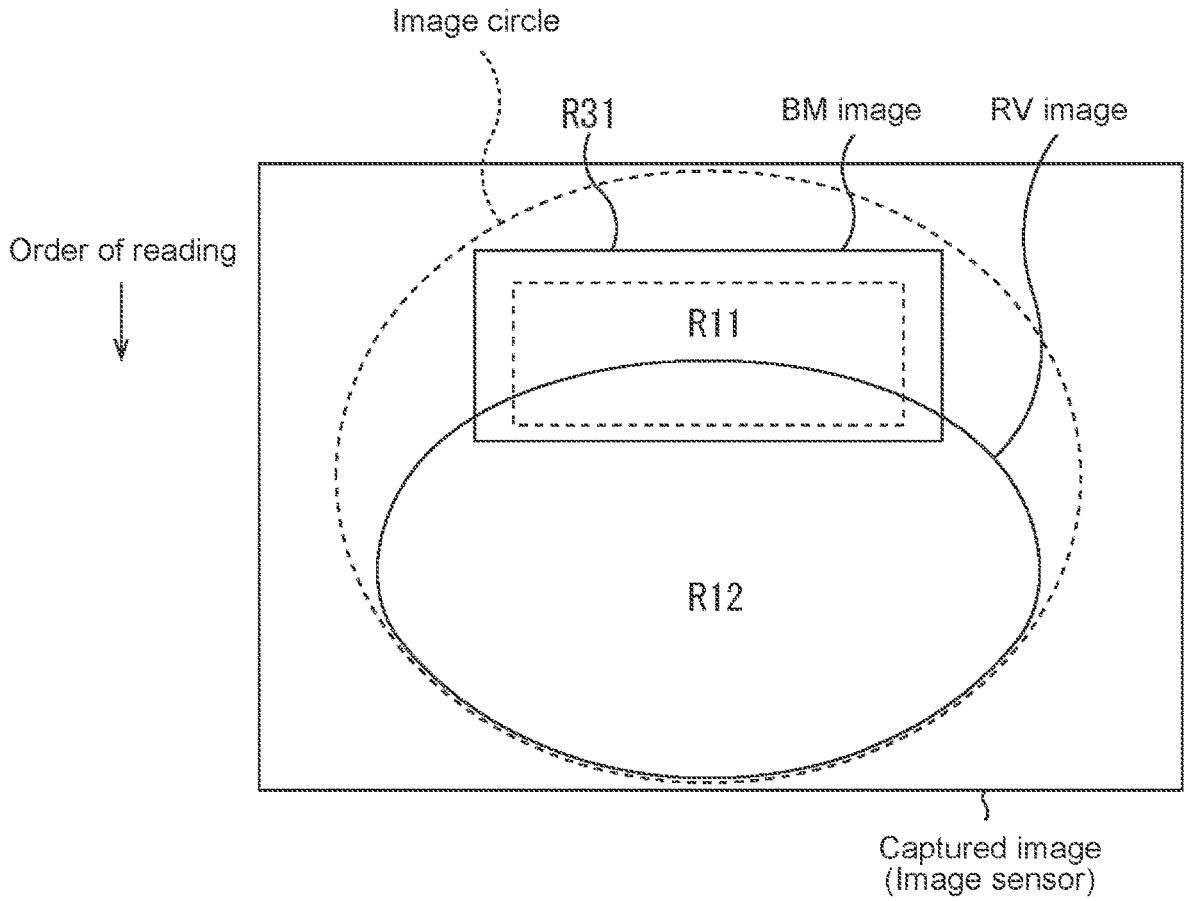


Image circle
R31
BM image
RV image
Order of reading
R11
R12
Captured image
(Image sensor)

FIG.24

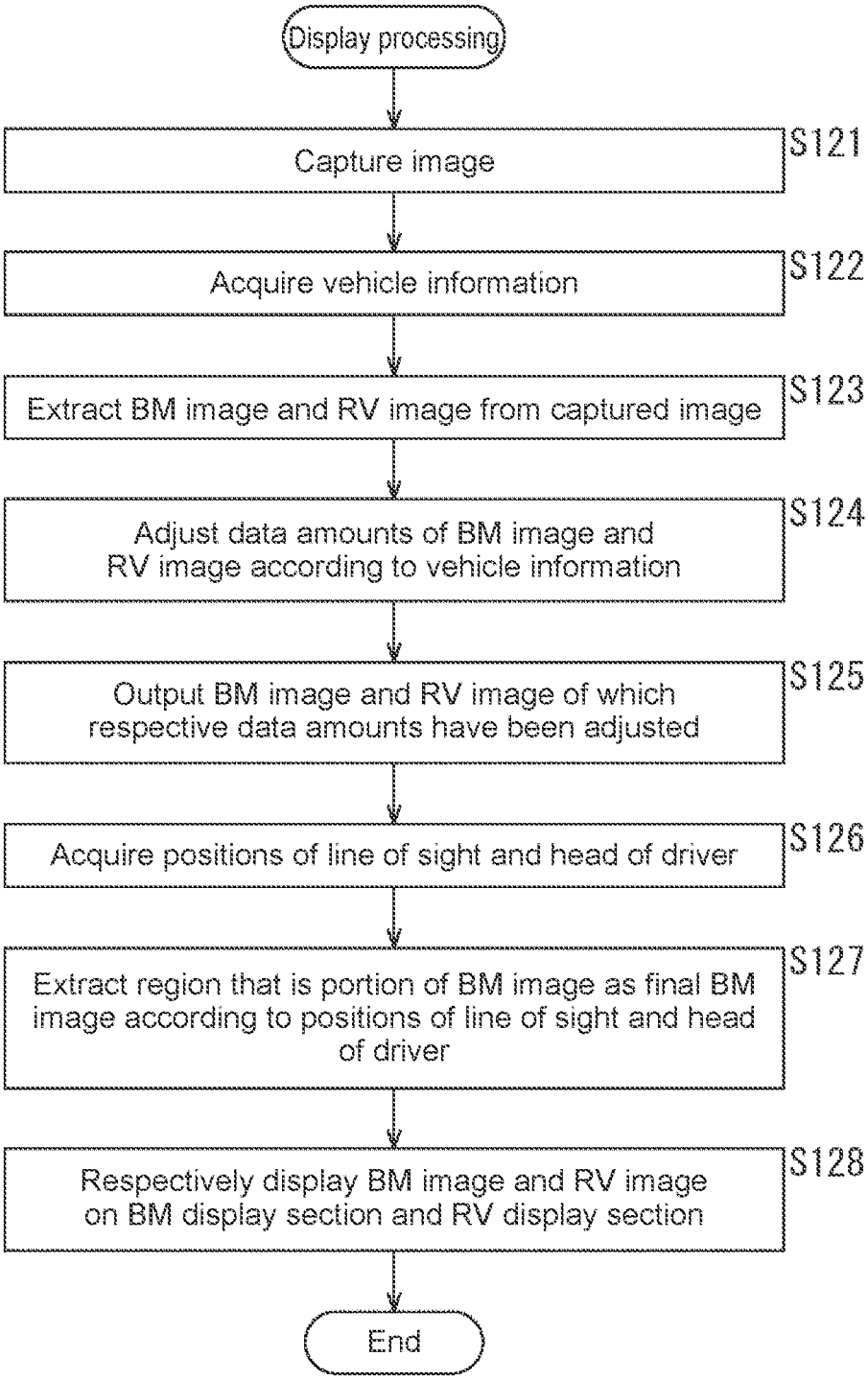

Display processing
Capture image
S121
Acquire vehicle information
S122
Extract BM image and RV image from captured image
S123
Adjust data amounts of BM image and RV image according to vehicle information
S124
Output BM image and RV image of which respective data amounts have been adjusted
S125
Acquire positions of line of sight and head of driver
S126
Extract region that is portion of BM image as final BM image according to positions of line of sight and head of driver
S127
Respectively display BM image and RV image on BM display section and RV display section
S128
End

FIG.25

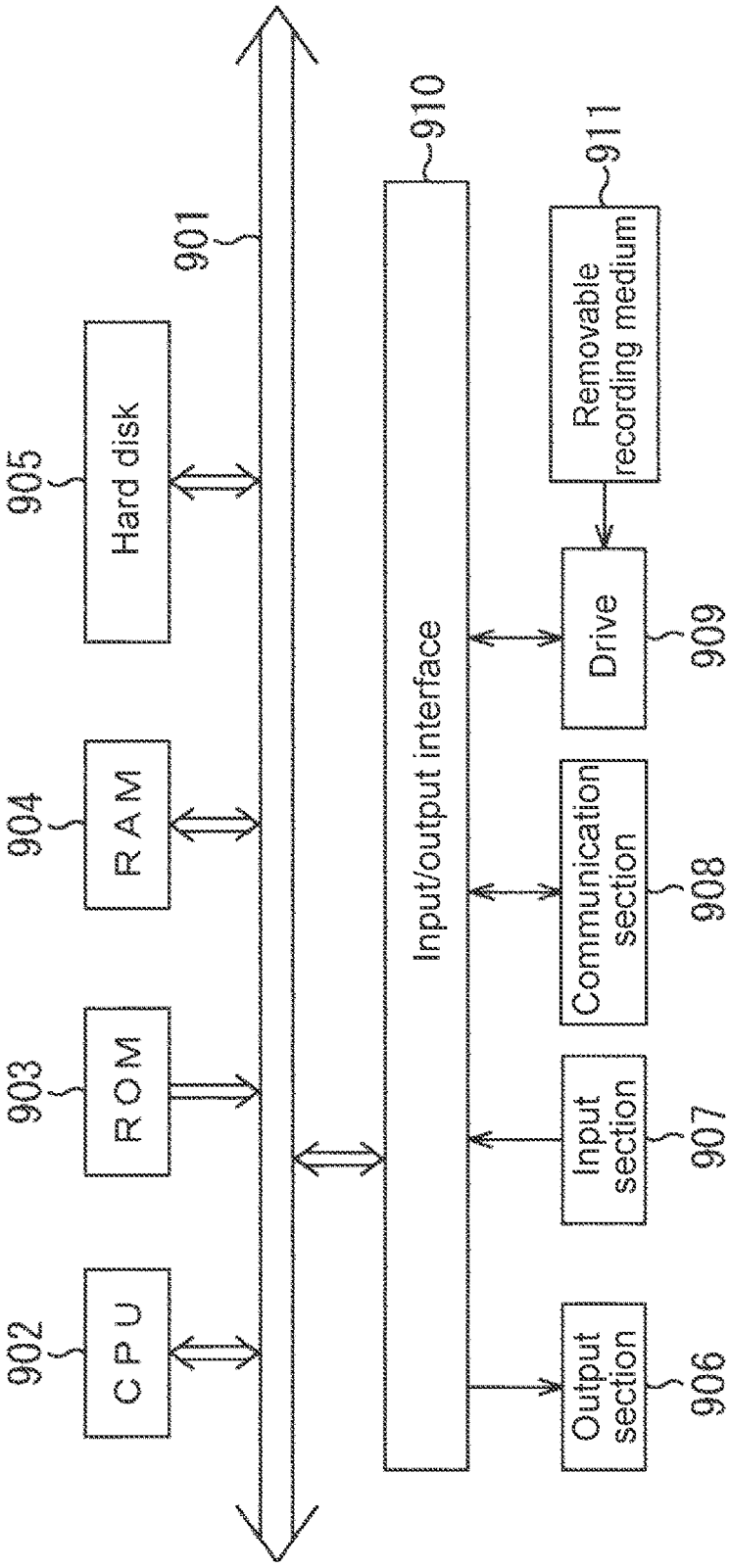

901
902
CPU
903
ROM
904
RAM
905
Hard disk
906
Output section
907
Input section
908
Communication section
909
Drive
910
Input/output interface
911
Removable recording medium

FIG.26

IMAGE-CAPTURING APPARATUS, CONTROL METHOD, AND PROGRAM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. § 371 as a U.S. National Stage Entry of International Application No. PCT/JP2019/041037, filed in the Japanese Patent Office as a Receiving Office on Oct. 18, 2019, which claims priority to Japanese Patent Application Numbers JP2019-039216, filed in the Japanese Patent Office on Mar. 5, 2019; and JP2018-204836, filed in the Japanese Patent Office on Oct. 31, 2018, each of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present technology relates to an image-capturing apparatus, a control method, and a program. In particular, the present technology relates to, for example, an image-capturing apparatus, a control method, and a program that make it possible to easily provide an image suitable for the operation of a vehicle.

BACKGROUND ART

For example, a viewing system in which a camera that is an image-capturing apparatus is installed in the rear of a vehicle such as an automobile and an image of a region behind the vehicle that is captured using the camera is displayed, is proposed.

Examples of the image of a region behind a vehicle that is provided by the viewing system include an image of a region situated further rearward than a region just behind the rear of the vehicle, and an image of the region just behind the rear of the vehicle.

Here, the image of a region situated further rearward than a region just behind the rear of a vehicle is, for example, an image that corresponds to an image seen in a Class I mirror, which is a so-called interior rearview mirror, and is hereinafter also referred to as a back mirror (BM) image. Further, the image of a region just behind the rear of a vehicle is an image of the rear of the vehicle and a region just behind the rear of the vehicle, and is hereinafter also referred to as a rearview (RV) image.

A vehicle is inclined when the vehicle starts going up or down a hill or is traveling on an uneven road surface. Further, the vehicle may also be inclined according to, for example, an object loaded on the vehicle or a state of an occupant of the vehicle.

When the vehicle is inclined, a camera installed in the vehicle is also inclined, and this results in the ratio (the proportion) of the sky, a road, and the like in a BM image being changed from the ratio when the vehicle is not inclined.

When the vehicle is not inclined and when the viewing system is adjusted such that a BM image suitable for the operation of a vehicle is displayed, the BM image suitable for the operation of the vehicle will not be displayed in some cases if the ratio of the sky, a road, and the like in the BM image is changed due to the inclination of the vehicle.

For example, when the vehicle is traveling on a flat road surface, a BM image is displayed that enables a driver to sufficiently recognize, for example, another vehicle that is getting close to the vehicle from behind, or an obstacle behind the vehicle. On the other hand, when the vehicle is inclined, the BM image may include less information necessary for the driver to recognize the other vehicle or the obstacle.

Thus, for example, a technology has been proposed that stores a captured image in a storage and cuts a necessary image out of the captured image when the vehicle is traveling up or down a hill, the captured image being captured using a camera, the storage being situated posterior to the camera (for example, refer to Patent Literature 1).

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Patent No. 6245274

DISCLOSURE OF INVENTION

Technical Problem

When a necessary image is cut out of a captured image stored in the storage, there is a need to read, from the camera, a captured image having a size significantly larger than the size (the number of pixels) of the necessary image. A large size of a captured image read from the camera results in a decrease in frame rate.

Further, there is a demand for a proposal of a technology that makes it possible to easily provide an image suitable for the operation of a vehicle, in addition to the technology that cuts a necessary image out of a captured image stored in a storage situated posterior to a camera.

The present technology has been made in view of the circumstances described above, and is intended to make it possible to easily provide an image suitable for the operation of a vehicle.

Solution to Problem

An image-capturing apparatus according to the present technology is an image-capturing apparatus that includes an image sensor that captures an image displayed on a display section of a vehicle; and a controller that controls reading of the image from the image sensor on the basis of vehicle information acquired by the vehicle.

A control method or a program according to the present technology is a control method or a program, the control method including controlling reading of an image from an image sensor that captures the image, on the basis of vehicle information acquired by a vehicle, the image being displayed on a display section of the vehicle, the program causing a computer to operate as a controller that performs such control.

In an image-capturing apparatus, a control method, and a program according to the present technology, reading of an image from an image sensor that captures the image is controlled on the basis of vehicle information acquired by a vehicle, the image being displayed on a display section of the vehicle.

Note that the image-capturing apparatus may be an independent apparatus or an internal block included in a single apparatus.

Further, the program can be provided by being transmitted through a transmission medium or by being stored in a recording medium.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view illustrating an external configuration example of a vehicle **10** that includes a viewing system according to the present technology.

FIG. **2** is a perspective view illustrating an example of a configuration of the interior of the vehicle **10**.

FIG. **3** is a block diagram illustrating a first example of a configuration of the viewing system included in the vehicle **10**.

FIG. **4** is a diagram describing an example of a control of reading of a BM image and an RV image that are images read from a captured image, the control being performed by a controller **43**.

FIG. **5** is a diagram describing a first example of a relationship between a state of the vehicle **10** and a BM image.

FIG. **6** is a diagram describing an example of a control of reading of a read image that is performed by the controller **43** according to inclination information.

FIG. **7** illustrates an example of a configuration of an image sensor **32**.

FIG. **8** is a flowchart describing an example of display processing of displaying a BM image that is performed in the first example of the configuration of the viewing system.

FIG. **9** is a block diagram illustrating a second example of the configuration of the viewing system included in the vehicle **10**.

FIG. **10** is a diagram describing a second example of a relationship between a state of the vehicle **10** and a BM image.

FIG. **11** is a diagram describing an example of a control of reading of a read image that is performed by a controller **71** according to inclination information.

FIG. **12** is a diagram further describing an example of the control of reading of a read image that is performed by the controller **71** according to inclination information.

FIG. **13** is a flowchart describing an example of display processing of displaying a BM image that is performed in the second example of the configuration of the viewing system.

FIG. **14** is a block diagram illustrating a third example of the configuration of the viewing system included in the vehicle **10**.

FIG. **15** is a diagram describing an example of a control of reading of a read image that is performed by the controller **71** according to inclination information.

FIG. **16** is a flowchart describing an example of display processing of displaying a BM image that is performed in the third example of the configuration of the viewing system.

FIG. **17** is a block diagram illustrating a fourth example of the configuration of the viewing system included in the vehicle **10**.

FIG. **18** illustrates an example of an image that can be output by the image sensor **32**.

FIG. **19** is a diagram describing an example of a vehicle transmission bandwidth that can be used for data transmission in the vehicle **10**.

FIG. **20** is a diagram describing a first example of a control of adjustment of data amounts of a BM image and an RV image, the control being performed by a controller **136**.

FIG. **21** is a diagram describing a second example of the control of adjustment of data amounts of a BM image and an RV image, the control being performed by the controller **136**.

FIG. **22** is a flowchart describing an example of display processing of displaying a BM image and an RV image that is performed in the viewing system.

FIG. **23** is a block diagram illustrating a fifth example of the configuration of the viewing system included in the vehicle **10**.

FIG. **24** is a diagram describing an example of a control of extraction of a BM image and an RV image from a captured image, the control being performed by a controller **181**.

FIG. **25** is a flowchart describing an example of display processing of displaying a BM image and an RV image that is performed in the viewing system.

FIG. **26** is a block diagram illustrating an example of a configuration of an embodiment of a computer to which the present technology is applied.

MODE(S) FOR CARRYING OUT THE INVENTION

Example of Configuration of Vehicle Including Viewing System

FIG. **1** is a perspective view illustrating an example of a configuration of an appearance of a vehicle **10** that includes a viewing system to which the present technology is applied.

For example, a camera unit **11** that is an image-capturing apparatus used to capture an image of a region behind the (four-wheeled) vehicle **10** is installed in the rear of the vehicle **10**. In FIG. **1**, the camera unit **11** is installed above a rear window of the vehicle **10**.

The camera unit **11** is a wide-angle camera unit (for example, the angle of view is 120 degrees or more) such that it is possible to capture an image in which both a range corresponding to a BM image and a range corresponding to an RV image appear. Further, the camera unit **11** is a high-resolution camera unit (for example, a resolution of 4K or more) such that a distant subject is apparent in the BM image. Thus, the camera unit **11** is capable of capturing a wide-angle, high-resolution image.

Note that, in the camera unit **11**, a BM image and an RV image are extracted from an image captured by the camera unit **11** (hereinafter also referred to as a captured image). This will be described later.

The camera unit **11** is installed in a state in which the orientation of the optical axis has been adjusted, such that the BM image includes an image of a state of a region situated further rearward than a region just behind the rear of the vehicle **10**, and such that the RV image includes an image of states of the rear of the vehicle **10** and the region just behind the rear of the vehicle **10**, the state of the region situated further rearward than the region just behind the rear of the vehicle **10** being a state that can be observed using an interior rearview mirror (a Class I mirror in Regulation No. 46 defined by the United Nations Economic Commission for Europe <UNECE>) when the interior rearview mirror is installed in the vehicle **10**.

Thus, the BM image is an image of a state of a region situated further rearward than a region just behind the rear of the vehicle **10**, the state being a state that can be observed using an interior rearview mirror when the interior rearview mirror is installed in the vehicle **10**. Further, the RV image is an image of states of the rear of the vehicle **10** and the region just behind the rear of the vehicle **10**. The RV image is particularly useful when the vehicle **10** is traveling backward, since a region just behind the rear of the vehicle **10** that is a blind spot of the interior rearview mirror appears in the RV image. Further, the RV image can be used to generate an overhead image obtained when the vehicle **10** is viewed from above.

Note that the camera unit **11** is not limited to being installed above the rear window of the vehicle **10** as long as it is possible to capture a captured image from which the BM

image and the RV image described above can be extracted. For example, in addition to being installed above the rear window of the vehicle **10**, the camera unit **11** may be installed at, for example, a position P**11** above a license plate situated in the rear of the vehicle **10**.

FIG. **2** is a perspective view illustrating an example of a configuration of the interior of the vehicle of FIG. **1**.

A BM display section **21** that displays thereon a BM image is provided at a position, in the vehicle **10**, at which the interior rearview mirror is installed. The BM display section **21** is a display section that is an alternative to the interior rearview mirror.

An RV display section **22** that displays thereon an RV image is provided at a center position of a dashboard in the vehicle **10**.

Note that an in-vehicle camera **23** used to capture an image of a driver is provided on the side of a driver's seat of the dashboard in the vehicle **10**. An image of the driver is captured to be output by the in-vehicle camera **23**. In the vehicle **10**, positions of the line of sight and the head of the driver are detected from the image of the driver.

Here, the in-vehicle camera **23** used to capture an image of the driver may be provided at any position other than a position on the dashboard, such as a position P**21** above the BM display section **21**.

First Example of Configuration of Viewing System

FIG. **3** is a block diagram illustrating a first example of a configuration of the viewing system included in the vehicle **10**.

The viewing system includes the camera unit **11**, the BM display section **21**, and the RV display section described with reference to FIGS. **1** and **2**.

The camera unit **11** includes an optical system **31**, an image sensor **32**, an output section **33**, an acquisition section **41**, a detector **42**, and a controller **43**.

The optical system **31** includes optical components such as a condenser and a diaphragm, and collects light entering the optical system **31** onto the image sensor **32**.

The image sensor **32** receives light from the optical system **31** and performs photoelectric conversion to capture a captured image that includes images that are a BM image and an RV image. Then, in accordance with control performed by the controller **43**, the image sensor **32** reads (the images that are) the BM image and the RV image from the captured image to output the read images. Here, the image read from the captured image and output by the image sensor **32** is also referred to as a read image. The read image output by the image sensor **32** is supplied to the output section **33**.

The output section **33** is an output interface (IF) that transmits, to the outside of the camera unit **11**, the BM image and the RV image that are read images from the image sensor **32**. The output section **33** transmits the BM image to the BM display section **21**, and transmits the RV image to the RV display section **22**. The BM image from the output section **33** is displayed on the BM display section **21** in accordance with the specification of the BM display section **21**, and the RV image from the output section **33** is displayed on the RV display section **22** in accordance with the specification of the RV display section **22**. The output section **33** is capable of performing a format conversion and other image processing on the BM image and the RV image as necessary.

The acquisition section **41** acquires (receives), from the vehicle **10** and through a network (a vehicle information network) established in the vehicle **10**, vehicle information acquired by the vehicle **10**, and supplies the acquired vehicle information to the detector **42**.

Here, examples of the vehicle information include any information that can be acquired by the vehicle **10**, such as gyroscopic information obtained from a gyroscope of the vehicle **10**, suspension information regarding a suspension of the vehicle **10**, a front camera image obtained from a front camera used to capture an image of a region ahead of the vehicle **10**, GPS information obtained from the Global Positioning System (GPS), traveling information that indicates a traveling state of the vehicle **10** such as a vehicle speed and a traveling direction (forward or backward), positions of the line of sight and the head of a driver of the vehicle **10** that are obtained from an image captured using the in-vehicle camera **23**, a three-dimensional (3D) map used for the navigation system of the vehicle **10**, and a high-definition map used for an advanced driving assist system (ADAS)/an autonomous driving system. For example, it is possible to adopt, as the vehicle speed, speed information that is output by a speed sensor when the vehicle **10** includes the speed sensor. For example, it is possible to adopt, as the traveling direction, gear information that indicates a state of the transmission.

The acquisition section **41** acquires at least one piece of vehicle information as necessary, and supplies the at least one piece of vehicle information to the detector **42**.

In the first example of the configuration of the viewing system, the acquisition section **41** acquires, for example, gyroscopic information, or GPS information and a 3D map (a high-definition map) as the vehicle information, and supplies the acquired vehicle information to the detector **42**.

Using the vehicle information from the acquisition section **41**, the detector **42** detects (calculates) inclination information that indicates the inclination of the vehicle **10**, and supplies the detected inclination information to the controller **43**.

The controller **43** controls reading of the read image from the image sensor **32** on the basis of the vehicle information.

For example, the controller **43** controls the reading of the read image from the image sensor **32** according to the inclination information detected by the detector **42** using the vehicle information.

In other words, according to the inclination information supplied from the detector **42**, the controller calculates, from a captured image captured by the image sensor **32**, a reading-start position for an image that starts being read as a read image, sets the size (the number of pixels) of the read image, and supplies, to the image sensor **32**, a reading position specified by the reading-start position and the size. Accordingly, the controller **43** performs a reading control for controlling reading of a read image from the image sensor **32**.

The image sensor **32** reads a pixel signal of a pixel of the reading position supplied from the controller **43**, and outputs a read image that exhibits a pixel value corresponding to the pixel signal.

Note that, in addition to being specified by the reading-start position and the size, the reading position can be specified by, for example, the reading-start position and a reading-termination position at which reading of a read image is terminated.

Here, in the first example of the configuration of the viewing system, a read image output by the image sensor **32** is the same as a BM image displayed on the BM display section **21** or an RV image displayed on the RV display section **22**. Thus, in the first example of the configuration of the viewing system, the size of the BM image displayed on

the BM display section **21** or the size of the RV image displayed on the RV display section **22** is set to be the size of a read image.

<Control of Reading of Read Image from Captured Image>

FIG. **4** is a diagram describing an example of a control of reading of a BM image and an RV image that are images read from a captured image, the control being performed by the controller **43**.

Regarding a positional relationship between the optical system **31** and a captured image captured by the image sensor **32**, the captured image (a light-receiving surface of the image sensor **32**) includes an image circle of (a lens included in) the optical system **31**, as illustrated in, for example, FIG. **4**.

In the reading control, the controller **43** controls reading of a pixel signal from the image sensor **32** such that a specified region R**11** is extracted from a captured image as a BM image, the specified region R**11** being a region in which a region situated further rearward than a region just behind the rear of the vehicle **10** appears (a region observed using an interior rearview mirror if the interior rearview mirror is installed in the vehicle **10**). In other words, the controller **43** controls reading of a pixel signal from the image sensor **32** according to a display device or the type (/ an application) of image-display function.

Further, in the reading control, the controller **43** controls reading of a pixel signal from the image sensor **32** by supplying a reading position for a read image to the image sensor **32**, such that a specified region R**12** is extracted as an RV image from (an image in the image circle from among) the captured image, the specified region R**12** being a region in which the rear of the vehicle **10** and the region just behind the rear of the vehicle **10** appear.

In accordance with control performed by the controller **43**, the image sensor **32** reads, from a captured image obtained by performing image-capturing, a pixel signal of the region R**11** that corresponds to (a pixel value of) the BM image, and outputs a read image that exhibits the pixel value corresponding to the pixel signal. Further, the image sensor **32** reads, from the captured image, a pixel signal of the region R**12** that corresponds to the RV image, and outputs a read image that exhibits a pixel value corresponding to the pixel signal.

The regions R**11** and R**12** are each specified by a reading position for a read image that is supplied from the controller **43** to the image sensor **32**.

Note that, in the control of reading of a BM image that is a read image, the controller **43** can also calculate a reading position according to, for example, positions of the line of sight and the head of a driver that are included in vehicle information, the reading position being used to specify the region R**11** extracted as the BM image.

In other words, if a rearview mirror is installed in the vehicle **10**, a range that appears in an image that can be seen by a driver using the rearview mirror will be changed as the driver moves his/her line of sight or his/her head. In the control of reading of a BM image that is a read image, the controller **43** can also calculate a reading position according to the positions of the line of sight and the head of the driver, such that the driver can see a BM image of a range similar to the range in an image that can be observed when the rearview mirror is installed in the vehicle **10**, the reading position being used to specify the region R**11** extracted as the BM image.

In order to simplify the description, the description of an RV image is omitted below.

<Relationship Between State of Vehicle **10** and BM Image>

FIG. **5** is a diagram describing a first example of a relationship between a state of the vehicle **10** and a BM image.

FIG. **5**(A**1**) illustrates a state of the vehicle **10** when the vehicle **10** is traveling on a flat road surface. Further, FIG. **5**(A**2**) illustrates an example of a BM image obtained when the vehicle **10** is traveling on the flat road surface.

FIG. **5**(B**1**) illustrates a state of the vehicle **10** when the vehicle **10** starts traveling downhill. Further, FIG. **5**(B**2**) illustrates an example of a BM image obtained when the vehicle **10** starts traveling downhill.

FIG. **5**(C**1**) illustrates a state of the vehicle **10** when the vehicle **10** starts traveling uphill. Further, FIG. **5**(C**2**) illustrates an example of a BM image obtained when the vehicle **10** starts traveling uphill.

Here, the range of a three-dimensional space in the BM image is referred to as a BM range. Further, in the following description, it is assumed that positions of the line of sight and the head of a driver are fixed in order to simplify the description. Therefore, it is assumed that (a position of) the region R**11** extracted as a BM image from a captured image, and thus a BM range are not changed due to the driver moving the position of his/her line of sight or his/her head.

Further, it is assumed that, when the vehicle **10** is on a flat road surface (when the vehicle **10** is not inclined), the controller **43** performs a reading control, that is, a calculation of a reading position (a reading-start position and the size) such that a BM image in which a rear vehicle situated rearward a specified distance from the vehicle **10** appears substantially in the center of the view of the BM image is extracted, as illustrated in FIG. **5**.

In this case, when the vehicle **10** starts traveling downhill, the vehicle **10** is inclined to the front, that is, in a pitch direction, and the optical axis of the camera unit **11** installed in the rear of the vehicle **10**, and thus the BM range are upwardly inclined (toward the sky), compared to when the vehicle **10** is on a flat road surface (FIG. **5** (B**1**) and FIG. **5**(B**2**)).

Consequently, when camera settings are performed such that a rear vehicle situated rearward a specified distance from the vehicle **10** appears substantially in the center of the view of a BM image in a state in which the vehicle **10** is on a flat road surface (the vehicle **10** is traveling on a flat road surface), a BM image in which the rear vehicle situated rearward the specified distance from the vehicle **10** appears in a lower portion of the view of the BM image, is obtained in a state in which the vehicle **10** starts traveling downhill. As illustrated in FIG. **5**, the proportion of the sky (a region in which the sky appears) is larger and the proportion of a road is smaller in this BM image than a BM image obtained in a state in which the vehicle **10** is on a flat road surface.

Thus, an amount of information is changed in a BM image obtained when the vehicle **10** starts traveling downhill, compared to a BM image obtained when the vehicle is on a flat road surface. In other words, for example, an amount of information regarding a road is reduced in the BM image obtained when the vehicle **10** starts traveling downhill, compared to the BM image obtained when the vehicle **10** is on a flat road surface. Further, there is a possibility that, depending on a relative position of the vehicle **10** to a rear vehicle, or a state of the inclination of a downhill, a portion of the rear vehicle or the rear vehicle itself will not appear in a BM image.

On the other hand, when the vehicle **10** starts traveling uphill, the vehicle **10** is inclined to the back, that is, in the

pitch direction, and the optical axis of the camera unit **11** installed in the rear of the vehicle **10**, and thus the BM range are downwardly inclined (toward the road), compared to when the vehicle **10** is on a flat road surface (FIG. **5** (C**1**) and FIG. **5**(C**2**)).

Consequently, when camera settings are performed such that a rear vehicle situated rearward a specified distance from the vehicle **10** appears substantially in the center of the view of a BM image in a state in which the vehicle **10** is on a flat road surface, a BM image in which the rear vehicle situated rearward the specified distance from the vehicle **10** appears in an upper portion of the view of the BM image, is obtained in a state in which the vehicle **10** starts traveling uphill. As illustrated in FIG. **5**, the proportion of the sky (a region in which the sky appears) is smaller and the proportion of a road is larger in this BM image than a BM image obtained in a state in which the vehicle **10** is on a flat road surface.

Thus, an amount of information is changed in a BM image obtained when the vehicle **10** starts traveling uphill, compared to a BM image obtained when the vehicle **10** is on a flat road surface. In other words, for example, an amount of information regarding the sky is reduced in the BM image obtained when the vehicle **10** starts traveling uphill since the proportion of the sky is reduced, compared to the BM image obtained when the vehicle **10** is on a flat road surface. Further, there is a possibility that, depending on a relative position of the vehicle **10** to a rear vehicle, or a state of the inclination of an uphill, a portion of the rear vehicle or the rear vehicle itself will not appear in a BM image.

As described above, from the point of view of providing a driver of the vehicle **10** with a BM image suitable for the operation of the vehicle **10**, it is not favorable that the amount of information in a BM image obtained when the vehicle **10** starts traveling downhill or uphill be changed from the amount of information in a BM image obtained when the vehicle **10** is on a flat road surface.

Thus, in the control of reading of a BM image, the controller **43** controls, according to inclination information from the detector **42**, reading of a BM image corresponding to a read image from the image sensor **32**, such that a BM image having an amount of information similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, is obtained regardless of a state of the vehicle **10**.

<Control of Reading of Read Image That is Performed by Controller **43** According to Inclination Information>

FIG. **6** is a diagram describing an example of a control of reading of a read image that is performed by the controller **43** according to inclination information.

Here, it is assumed that, when the vehicle is on a flat road surface, a reading control is performed by the controller **43** such that (a pixel signal of a pixel of) a rectangular region R**101** is read from a captured image captured by the image sensor **32** (from the light-receiving surface of the image sensor **32**). The region R**101** has the same size as a BM image that is a read image.

For example, when the vehicle **10** starts traveling uphill and is inclined to the back, the controller **43** performs a reading control such that a reading position used to specify a region R**102** having the same size as the region R**101** is calculated according to inclination information, and a pixel signal of the calculated reading position is read, the region R**102** being shifted upward from the region R**101** by the number of pixels corresponding to an angle at which the vehicle **10** is inclined to the back.

Further, for example, when the vehicle **10** starts traveling downhill and is inclined to the front, the controller **43** performs a reading control such that a reading position used to specify a region R**103** having the same size as the region R**101** is calculated according to inclination information, and a pixel signal of the calculated reading position is read, the region R**103** being shifted downward from the region R**101** by the number of pixels corresponding to an angle at which the vehicle **10** is inclined to the front.

In the calculation of a reading position depending on inclination information, the reading position is calculated such that a read image in which a road and the sky appear in the same proportion as a BM image obtained when the vehicle **10** is on a flat road surface, is read, that is, such that the proportion between a road and the sky that appear in a read image is maintained the same as (/ is close to) the proportion in a BM image obtained when the vehicle **10** is on a flat road surface.

It is possible to easily obtain an image suitable for the operation of the vehicle **10** by the reading control described above being performed by the controller **43**. In other words, it is possible to easily obtain a BM image having an amount of information similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, regardless of the inclination of the vehicle **10** in the pitch direction.

In the first example of the configuration of the viewing system, the detector **42** detects a (steep) hill from, for example, gyroscopic information, or GPS information and a 3D map that are vehicle information supplied by the acquisition section **41**, and detects (calculates) inclination information regarding the vehicle when the vehicle **10** starts going up or down a hill, that is, inclination information that primarily indicates (the level of) the inclinations of the vehicle **10** to the front and to the back, that is, in the pitch direction. Then, the detector **42** supplies the inclination information to the controller **43**.

For example, the detector **42** can detect, using the gyroscopic information, that the vehicle **10** starts going up or down a hill, and can further detect inclination information that indicates the inclinations of the vehicle **10** to the front and to the back, that is, in the pitch direction at that time.

Further, for example, the detector **42** detects (estimates), from the current location obtained using the GPS information and from the 3D map, that the vehicle **10** starts going up or down a hill, and can further detect (estimate), using an inclination of the hill that is obtained using the 3D map, inclination information that indicates the inclinations of the vehicle **10** to the front and to the back, that is, in the pitch direction when the vehicle **10** starts going up or down the hill.

According to the inclination information from the detector **42**, the controller **43** calculates a reading position for an image read from the image sensor **32** as a read image, and supplies the calculated reading position to the image sensor **32**. Accordingly, the controller **43** controls reading of the read image from the image sensor **32**.

The image sensor **32** reads a pixel signal of a pixel of the reading position supplied from the controller **43**, and outputs a read image that exhibits a pixel value corresponding to the pixel signal.

Example of Configuration of Image Sensor **32**

FIG. **7** illustrates an example of a configuration of the image sensor **32** of FIG. **3**.

The image sensor **32** includes a pixel array **51**, an input circuit **52**, a row selecting circuit **53**, a column selecting circuit **54**, an analog-to-digital (AD) converter **55**, a line buffer **56**, and an output circuit **57**.

The pixel array **51** includes a plurality of pixels **61** arranged in a two-dimensional plane. A region, in the pixel array **51**, in which the pixels **61** are arranged is the light-receiving surface of the image sensor **32**.

The pixel **61** converts light entering the pixel **61** into a pixel signal that is an electrical signal corresponding to the amount of the light. A pixel signal of the pixel **61** in a row selected by the row selecting circuit and in a column selected by the column selecting circuit is read from the pixel array **51** through the column selecting circuit **54**, and the read pixel signal is supplied to the AD converter **55**.

A reading position specified by a reading-start position for a read image read from a captured image and by the size of the read image (hereinafter also referred to as a reading size) is supplied by the controller **43** to the input circuit **52**.

Using the reading-start position and the reading size that are the reading position from the controller **43**, the input circuit **52** calculates coordinates of the pixel **61** from among the pixels **61** of the pixel array that are reading-start coordinates (X_STA, Y_STA), and calculates coordinates of the pixel **61** from among the pixels **61** of the pixel array **51** that are reading-termination coordinates (X_END, Y_END), the pixel **61** for the reading-start coordinates (X_STA, Y_STA) being the pixel **61** at which reading of a pixel signal is started in, for example, raster scan order, the pixel **61** for the reading-termination coordinates (X_END, Y_END) being the pixel **61** at which reading of a pixel signal is terminated in, for example, raster scan order.

The input circuit **52** supplies a y-coordinate Y_STA of the reading-start coordinates (X_STA, Y_STA), and a y-coordinate Y_END of the reading-termination coordinates (X_END, Y_END) to the row selecting circuit **53**, and the input circuit **52** supplies an x-coordinate X_STA of the reading-start coordinates (X_STA, Y_STA) and an x-coordinate X_END of the reading-termination coordinates (X_END, Y_END) to the column selecting circuit **54** (a process PR**1**).

The row selecting circuit **53** sequentially selects rows from a row of the pixel **61** represented by the y-coordinate Y_STA received from the input circuit **52** up to a row of the pixel **61** represented by the y-coordinate Y_END received from the input circuit **52** (a process PR**2**).

In the pixel array **51**, a pixel signal is read from the pixel **61** in the row selected by the row selecting circuit **53**, and the read pixel signal is supplied to the column selecting circuit **54**.

From among the pixel signals read from the pixels **61**, the column selecting circuit **54** selects pixel signals of the pixels **61** in respective columns from a column of the pixel **61** represented by the x-coordinate X_STA received from the input circuit **52** up to a column of the pixel **61** represented by the x-coordinate X_END received from the input circuit **52**, and the column selecting circuit supplies the selected pixel signals to the AD converter (a process PR**3**).

The AD converter **55** performs AD conversion on a pixel signal from the column selecting circuit **54**, for example, per row, and supplies, to the line buffer **56**, the pixel signal on which AD conversion has been performed (a process PR**4**).

The line buffer **56** temporarily stores therein a pixel signal from the AD converter **55**.

The output circuit **57** reads a pixel signal stored in the line buffer **56** for each pixel (a process PR**5**), and outputs the read pixel signal to the outside of the image sensor **32** as a pixel value of the read image.

As described above, in the image sensor **32**, a pixel signal of the pixel **61** included in a read region is read, and an image that exhibits a pixel value corresponding to the pixel signal is read as a read image, the read region being a rectangular region that includes the pixel **61** of the reading-start coordinates (X_STA, Y_STA) as an upper-left vertex and the pixel **61** of the reading-termination coordinates (X_END, Y_END) as a lower-right vertex.

<Display Processing>

FIG. **8** is a flowchart describing an example of display processing of displaying a BM image that is performed in the first example of the configuration of the viewing system of FIG. **3**.

In Step S**11**, the acquisition section **41** acquires gyroscopic information, or GPS information and a 3D map as vehicle information, and supplies the vehicle information to the detector **42**. Then, the process moves on to Step S**12**.

In Step S**12**, the detector **42** detects a hill using the vehicle information from the acquisition section **41**. Further, the detector **42** detects (calculates), using the vehicle information from the acquisition section **41**, inclination information regarding the vehicle **10** when the vehicle **10** starts going up or down the hill (primarily, inclination information indicating the inclinations to the front and to the back, that is, in the pitch direction), and supplies the detected inclination information to the controller **43**. Then, the process moves on to Step S**13** from Step S**12**.

In Step S**13**, the controller **43** calculates, according to the inclination information from the detector **42**, a reading-start position for a read image from the image sensor **32**, and supplies the reading-start position and the size of a BM image to the image sensor **32** as a reading position. Then, the process moves on to Step S**14**.

In Step S**14**, the image sensor **32** reads a pixel signal of a pixel of the reading position supplied by the controller **43**, and acquires a read image that exhibits a pixel value corresponding to the pixel signal to output the acquired read image. The read image output by the image sensor **32** is supplied to the output section **33**, and the process moves on to Step S**15** from Step S**14**.

In Step S**15**, the output section **33** transmits, to the BM display section **21** and as a BM image, the read image from the image sensor **32**, and causes the read image to be displayed on the BM display section **21**. This results in the BM image being displayed on the BM display section **21**, and the displaying processing is terminated.

As described above, in the first example of the configuration of the viewing system, inclination information is detected that primarily indicates the inclinations to the front and to the back, that is, in the pitch direction, and reading of a read image from the image sensor **32** is controlled according to the inclination information. Thus, it is possible to easily provide an image suitable for the operation of the vehicle **10**. In other words, a BM image having an amount of information similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, can be easily provided when the vehicle **10** starts going up or down a hill.

Further, in the first example of the configuration of the viewing system, a read image having the same size as a BM image is read from the image sensor in the reading control. Thus, it is possible to reduce the possibility of reducing the frame rate of the BM image, compared to when an image larger in size than the BM image is read from the image sensor **32**.

Gyroscopic information as well as GPS information and a 3D map have been described as examples of the vehicle information in the first configuration example. However, as in a second configuration example or a third configuration example described later, suspension information, a front camera image, or the like may be used as the vehicle

information in the first configuration example. The inclination of the vehicle may be detected using the suspension information, the front camera image, or the like.

Second Example of Configuration of Viewing System

FIG. **9** is a block diagram illustrating the second example of the configuration of the viewing system included in the vehicle **10**.

Note that, in the figure, a portion corresponding to that in FIG. **3** is denoted by the same reference numeral as FIG. **3**, and a description thereof is omitted below.

In FIG. **9**, the viewing system includes the camera unit **11**, the BM display section **21**, and the RV display section **22**. Further, the camera unit **11** in FIG. **9** includes the optical system **31**, the image sensor **32**, the output section **33**, the acquisition section **41**, the detector **42**, a controller **71**, and a processing section **72**.

Thus, the second example of the configuration of the viewing system of FIG. **9** is similar to the configuration of the viewing system of FIG. **3** in including the camera unit **11**, the BM display section **21**, and the RV display section **22**.

However, the second example of the configuration of the viewing system of FIG. **9** is different from the configuration of the viewing system of FIG. **3** in that the camera unit **11** includes the controller **71** instead of the controller **43**, and newly includes the processing section **72**.

As in the case of the controller **43**, the controller **71** controls reading of a read image from the image sensor **32** according to inclination information supplied by the detector **42**.

However, according to the inclination information supplied by the detector **42**, the controller **71** calculates a reading-start position for and the reading size of a read image from a captured image captured by the image sensor **32**, and the controller **71** supplies a reading position specified by the reading-start position and the reading size to the image sensor **32**.

In other words, in the first example of the configuration of the viewing system, the reading size is set to the size of a BM image since the size of a read image is the same as the size of the BM image. On the other hand, in the second example of the configuration of the viewing system, the reading size is calculated according to inclination information.

Here, in the second example of the configuration of the viewing system, the acquisition section **41** acquires, for example, suspension information as vehicle information, and supplies the acquired vehicle information to the detector **42**.

In this case, the detector **42** detects the inclination to the left and to the right, that is, in a roll direction using the suspension information from the acquisition section **41**, and detects (calculates) inclination information that indicates (the level of) the inclination. Then, the detector **42** supplies the inclination information to the controller **71**.

According to the inclination information from the detector **42**, the controller **71** calculates a rotation angle used to rotate the read image output by the image sensor **32**, and supplies the calculated rotation angle to the processing section **72**. The controller **71** supplies the rotation angle to the processing section **72** as described above to control a rotation of a read image that is performed by the processing section **72**, such that the read image is rotated by the rotation angle.

The read image output by the image sensor **32** is supplied to the processing section **72**.

The processing section **72** rotates the read image according to the rotation angle from the controller **71**. Further, the processing section **72** cuts an image having a size of a BM image (hereinafter also referred to as a BM size) out of the rotated read image, and supplies the obtained image to the output section **33** as the BM image.

As described above, in the processing section **72**, a read image is rotated and an image having a BM size is cut out of the rotated read image. Thus, it is necessary that the read image be an image having a size in which an image having a BM size can be cut out of the read image after rotation.

Thus, for example, the controller **71** calculates, as a reading size and according to inclination information, a smallest size of a read image such that an image having a BM size can be cut out of the read image after rotation.

<Relationship Between State of Vehicle **10** and BM Image>

FIG. **10** is a diagram describing a second example of a relationship between a state of the vehicle **10** and a BM image.

FIG. **10**(A**1**) illustrates a state of the vehicle **10** when the vehicle **10** is traveling on a flat road surface. Further, FIG. **10**(A**2**) illustrates an example of a BM image obtained when the vehicle **10** is traveling on the flat road surface.

FIG. **10**(B**1**) illustrates a state of the vehicle **10** when the vehicle **10** is on a road surface that has a difference in level and of which the right side is higher than its left side in a direction in which a front side of the vehicle **10** is oriented. Further, FIG. **10**(B**2**) illustrates an example of a BM image obtained when the vehicle **10** is on the road surface that has a difference in level and of which the right side is higher than its left side in the direction in which the front side of the vehicle **10** is oriented.

FIG. **10**(C**1**) illustrates a state of the vehicle **10** when the vehicle **10** is on a road surface that has a difference in level and of which the left side is higher than its right side in the direction in which the front side of the vehicle **10** is oriented. Further, FIG. **10**(C**2**) illustrates an example of a BM image obtained when the vehicle **10** is on the road surface that has a difference in level and of which the left side is higher than its right side in the direction in which the front side of the vehicle **10** is oriented.

It is assumed that, in FIG. **10**, the region R**11** extracted from a captured image as a BM image is not changed due to a driver moving a position of his/her line of sight or his/her head, as in the case of FIG. **5**.

In this case, when the vehicle **10** is on a road surface that has a difference in level and of which the right side is higher than its left side in the direction in which the front side of the vehicle **10** is oriented, the vehicle **10** is inclined to the left, that is, in the roll direction, and the camera unit **11** installed in the rear of the vehicle **10** is also inclined in the roll direction.

Consequently, when the vehicle **10** is on a flat road surface (FIG. **10**(A)), a horizontal line that extends horizontally appears in a BM image. When the vehicle **10** is on a road surface that has a difference in level and of which the right side is higher, a BM image in which the horizontal line appears in a state of being inclined diagonally downward right (diagonally upward left) is obtained (FIG. **10**(B)). As illustrated in FIG. **10**, there is a change in ranges of the sky and a road that appear in this BM image, compared to the BM image obtained when the vehicle **10** is on a flat road surface. In other words, in the BM image (FIG. **10**(B)) obtained when the vehicle **10** is on a road surface that has a

difference in level and of which the right side is higher, the proportion of the road on the right is smaller and the proportion of the sky on the right is larger, and the proportion of the road on the left is larger and the proportion of the sky on the left is smaller, compared to the BM image obtained when the vehicle is on a flat road surface.

Thus, there is a change in content of the BM image obtained when the vehicle **10** is on a road surface that has a difference in level and of which the right side is higher, compared to the BM image obtained when the vehicle **10** is on a flat road surface.

On the other hand, when the vehicle **10** is on a road surface that has a difference in level and of which the left side is higher than its right side in the direction in which the front side of the vehicle **10** is oriented, the vehicle **10** is inclined to the right, that is, in the roll direction, and the camera unit **11** installed in the rear of the vehicle **10** is also inclined in the roll direction.

Consequently, when the vehicle **10** is on a road surface that has a difference in level and of which the left side is higher, a BM image in which the horizontal line appears in a state of being inclined diagonally upward right (diagonally downward left) is obtained (FIG. **10**(C)). As illustrated in FIG. **10**, there is a change in ranges of the sky and a road that appear in this BM image, compared to the BM image obtained when the vehicle **10** is on a flat road surface. In other words, in the BM image (FIG. **10**(C)) obtained when the vehicle **10** is on a road surface that has a difference in level and of which the left side is higher, the proportion of the road on the right is larger and the proportion of the sky on the right is smaller, and the proportion of the road on the left is smaller and the proportion of the sky on the left is larger, compared to the BM image obtained when the vehicle **10** is on a flat road surface.

Thus, there is a change in content of the BM image obtained when the vehicle **10** is on a road surface that has a difference in level and of which the left side is higher, compared to the BM image obtained when the vehicle **10** is on a flat road surface.

As described above, from the point of view of providing a driver of the vehicle **10** with a BM image suitable for the operation of the vehicle **10**, it is not favorable that there be a change in BM image from a BM image obtained when the vehicle **10** is on a flat road surface to a BM image obtained when the vehicle **10** is on a road surface that has a difference in level and of which the left side or the right side is higher.

Thus, in the control of reading of a BM image, the controller **71** controls, according to inclination information from the detector **42**, reading of a BM image corresponding to a read image from the image sensor **32**, such that a BM image having an amount of information similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, is obtained regardless of a state of the vehicle **10**.

<Control of Reading of Read Image That is Performed by Controller **71** According to Inclination Information>0126

FIG. **11** is a diagram describing an example of a control of reading of a read image that is performed by the controller **71** according to inclination information.

FIG. **11**(A) on the left illustrates read regions on the image sensor **32** with respect to respective cases. FIG. **11**(B) on the right illustrates a region cut out by the processing section **72**.

As described with reference to FIG. **6**, it is assumed that, when the vehicle **10** is on a flat road surface, a reading control is performed by the controller **71** such that (a pixel signal of a pixel of) the rectangular region R**101** having the same size as a BM image is read from a captured image captured by the image sensor **32** (from the light-receiving surface of the image sensor **32**).

For example, when the vehicle **10** is on a road surface having a difference in level and is inclined in the roll direction, the controller **71** performs a reading control such that a reading position used to specify a region R**111** that is larger in size than the region R**101** by the number of pixels corresponding to an angle of the inclination of the vehicle **10** in the roll direction, is calculated according to inclination information, and a pixel signal of the calculated reading position is read.

Here, as illustrated in FIG. **10**, the horizontal line that appears to extend horizontally in a BM image obtained when the vehicle **10** is on a flat road surface, is inclined in a BM image obtained when the vehicle **10** is inclined in the roll direction.

Thus, a read image output by the image sensor **32** according to a reading control is rotated by the processing section **72** such that the horizontal line appearing in the read image extends horizontally, and (an image that corresponds to) the BM image is cut out of the rotated read image.

For example, in the calculation of a reading position depending on inclination information, a reading-start position and a reading size that are a reading position used to specify the region R**111** being centered at the center (the center of gravity) of the region R**101** and having a smallest size such that a BM image can be cut out of a read image after rotation, are calculated by the controller **71**, and the calculated reading-start position and reading size are supplied to the image sensor **32**.

Further, for example, a rotation angle used to rotate the region R**111** corresponding to a read image output by the image sensor **32** is calculated by the controller **71** according to inclination information, such that the horizontal line appearing in the region R**111** corresponding to the read image, appears to extend horizontally, and the calculated rotation angle is supplied by the controller **71** to the processing section **72**.

The rectangular region R**111** specified by the reading-start position and the reading size that are the reading position from the controller **71** is read by the image sensor **32** as a read image, and is supplied by the image sensor **32** to the processing section **72**.

The region R**111** that is the read image from the image sensor **32** is rotated by the processing section **72** by the rotation angle from the controller **71**. Then, a region R**113** that has the same size as the BM image and of which the angle of rotation is 0 degrees, is cut out of a region R**112** by the processing section **72** as the BM image, the region R**112** being obtained by rotating the region R**111** (FIG. **11**(B)).

With respect to a read image of FIG. **11**(A), the vehicle **10** is inclined to the right, that is, in the roll direction, and thus the horizontal line appearing in the read image is inclined diagonally upward right. Thus, the region R**111** that is the read image is rotated clockwise by the processing section **72** such that the horizontal line inclined diagonally upward right extends horizontally, and the region R**113** that is a BM image is cut out of the region R**112** by the processing section **72**, the region R**112** being obtained by the rotation.

Accordingly, it is possible to easily obtain, as a BM image, an image suitable for the operation of the vehicle **10**. In other words, it is possible to easily obtain a BM image having an amount of information similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, regardless of the inclination of the vehicle in the roll direction.

FIG. **12** is a diagram further describing an example of the control of reading of a read image that is performed by the controller **71** according to inclination information.

FIG. **12**(A) is a diagram describing the fact that the reading size of a read image obtained when the vehicle **10** is inclined in the roll direction is larger than the size of a BM image. FIG. **12**(B) is a diagram describing a rotation performed by the processing section **72**. FIG. **12**(C) is a diagram describing a cutout of the BM image that is performed by the processing section **72**.

In FIG. **12**(A), the vehicle **10** is inclined to the right, that is, in the roll direction, and thus the horizontal line appearing in the read image is inclined diagonally upward right.

In the second example of the configuration of the viewing system, the detector **42** detects, from suspension information that is vehicle information and is supplied by the acquisition section **41**, that the vehicle **10** is inclined in the roll direction, and detects (calculates) inclination information that indicates the inclination of the vehicle **10**, that is, inclination information that primarily indicates (the level of) the inclinations of the vehicle **10** to the left and to the right, that is, in the roll direction. Then, the detector **42** supplies the inclination information to the controller **71**.

According to the inclination information from the detector **42**, the controller **71** calculates a reading-start position for and the reading size of the region R**111** represented by a reading position for a read image read from the image sensor **32**, and the controller **71** supplies the calculated reading-start position and reading size to the image sensor **32**. When the vehicle **10** is inclined in the roll direction (when the angle of inclination in the roll direction is other than 0 degrees), the reading size is larger than the size of the region R**101** having the same size as the BM image.

Further, according to the inclination information from the detector **42**, the controller **71** calculates a rotation angle used to rotate the region R**111** that is the read image, and supplies the calculated rotation angle to the processing section **72**.

The image sensor **32** reads, as a read image, the region R**111** represented by the reading position (the reading-start position and the reading size) from the controller **71**, and outputs the read image.

The region R**111** that is the read image output by the image sensor **32** is supplied to the processing section **72**.

The region R**111** is rotated by the processing section **72** by the rotation angle from the controller **71**, and this results in generating the region R**112** in which the horizontal line appears to extend horizontally (FIG. **12**(B)). Further, the region R**113** having the same size as the region R**101** is cut out of the region R**112** by the processing section **72** as a BM image (FIG. **12**(B) and FIG. **12**(C)).

<Display Processing>

FIG. **13** is a flowchart describing an example of display processing of displaying a BM image that is performed in the second example of the configuration of the viewing system of FIG. **9**.

In Step S**21**, the acquisition section **41** acquires suspension information as vehicle information, and supplies the vehicle information to the detector **42**. Then, the process moves on to Step S**22**.

In Step S**22**, the detector **42** detects the inclination of the vehicle **10** in the roll direction using the vehicle information from the acquisition section **41**. Further, the detector **42** detects (calculates), using the vehicle information from the acquisition section **41**, inclination information regarding the vehicle **10** when the vehicle **10** is inclined in the roll direction (primarily, inclination information indicating the inclinations to the left and to the right, that is, in the roll direction), and supplies the detected inclination information to the controller **71**. Then, the process moves on to Step S**23** from Step S**22**.

In Step S**23**, the controller **71** calculates, according to the inclination information from the detector **42**, a reading-start position for and the reading size of a read image from the image sensor **32**, and supplies the reading-start position and the reading size to the image sensor **32** as a reading position. Further, the controller **71** calculates, according to the inclination information from the detector **42**, a rotation angle used to rotate the read image, and supplies the calculated rotation angle to the processing section **72**. Then, the process moves on to Step S**24** from Step S**23**.

In Step S**24**, the image sensor **32** reads a pixel signal of a pixel of the reading position supplied by the controller **71**, and acquires a read image that exhibits a pixel value corresponding to the pixel signal to output the acquired read image. The read image output by the image sensor **32** is supplied to the processing section **72**, and the process moves on to Step S**25** from Step S**24**.

In Step S**25**, the processing section **72** rotates the read image from the image sensor **32** by the rotation angle from the controller **71**. Further, the processing section **72** cuts a BM image out of the rotated read image, and supplies the BM image to the output section **33**. Then, the process moves on to Step S**26** from Step S**25**.

In Step S**26**, the output section **33** transmits, to the BM display section **21**, the BM image from the processing section **72**, and causes the BM image to be displayed on the BM display section **21**. This results in the BM image being displayed on the BM display section **21**, and the displaying processing is terminated.

As described above, in the second example of the configuration of the viewing system, inclination information is detected that primarily indicates the inclinations to the left and to the right, that is, in the roll direction, and reading of a read image from the image sensor **32** is controlled according to the inclination information. Further, in the second example of the configuration of the viewing system, a rotation of the read image is controlled according to the inclination information, and a BM image is cut out of the read image after the rotation. Thus, the second example of the configuration of the viewing system makes it possible to easily provide an image suitable for the operation of the vehicle **10**. In other words, a BM image having an amount of information similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, can be easily provided when the vehicle **10** is on a road surface having a difference in level between the left side and the right side.

Further, in the second example of the configuration of the viewing system, a read image having a smallest size such that a BM image can be cut out of the read image after rotation, is read from the image sensor **32** in the reading control. This makes it possible to reduce the possibility of reducing the frame rate of the BM image.

The suspension information has been described as an example of the vehicle information in the second configuration example. However, the gyroscopic information; the GPS information and the 3D map; the front camera image; or the like may be used as the vehicle information, as in the first configuration example described above, or in the third configuration example described later. Then, the inclination of the vehicle may be detected using the gyroscopic information; the GPS information and the 3D map; the front camera image; or the like.

Third Example of Configuration of Viewing System

FIG. **14** is a block diagram illustrating the third example of the configuration of the viewing system included in the vehicle **10**.

Note that, in the figure, a portion corresponding to that in FIG. **3** or **9** is denoted by the same reference numeral as FIG. **3** or **9**, and a description thereof is omitted below.

In FIG. **14**, the viewing system includes the camera unit **11**, the BM display section **21**, and the RV display section **22**. Further, the camera unit **11** in FIG. **14** includes the optical system **31**, the image sensor **32**, the output section **33**, the acquisition section **41**, the detector **42**, the controller **71**, and the processing section **72**.

Thus, the third example of the configuration of the viewing system of FIG. **14** is similar to the second example of the configuration of the viewing system of FIG.

However, in the third example of the configuration of the viewing system of FIG. **14**, the acquisition section **41** acquires, for example, suspension information or a front camera image as vehicle information, and supplies the acquired vehicle information to the detector **42**.

In this case, the detector **42** detects a state of the unevenness of a road surface using the suspension information or the front camera image from the acquisition section **41**. Further, the detector **42** detects the inclinations of the vehicle **10** to the front and to the back, that is, in the pitch direction as well as the inclinations of the vehicle **10** to the left and to the right, that is, in the roll direction due to the unevenness of the road surface, and detects (calculates) inclination information that indicates (the levels of) the inclinations. Then, the detector **42** supplies the inclination information to the controller **71**.

Here, in the first example of the configuration of the viewing system, reading of a read image from the image sensor **32** is controlled according to the inclinations of the vehicle **10** to the front and to the back, that is, in the pitch direction. In the second example of the configuration of the viewing system, reading of a read image from the image sensor **32**, and a rotation of the read image that is performed by the processing section are controlled according to the inclination of the vehicle **19** to the left and the right, that is, in the roll direction.

On the other hand, in the third example of the configuration of the viewing system, reading of a read image from the image sensor **32**, and a rotation of the read image that is performed by the processing section **72** are controlled according to the inclinations of the vehicle **10** to the front and to the back, that is, in the pitch direction, and according to the inclinations of the vehicle to the left and to the right, that is, in the roll direction.

Thus, in the third example of the configuration of the viewing system, a control obtained by combining the controls of reading of a read image from the image sensor **32** that are respectively performed in the first and second examples of the configuration of the viewing system, is performed as a control of reading of a read image from the image sensor **32**. Further, in the third example of the configuration of the viewing system, the same control as the control of a rotation of a read image that is performed in the second example of the configuration of the viewing system, is performed as a control of a rotation of a read image that is performed by the processing section **72**.

<Control of Reading of Read Image That is Performed by Controller **71** According to Inclination Information>0161

FIG. **15** is a diagram describing an example of a control of reading of a read image that is performed by the controller **71** according to inclination information.

FIG. **15**(A) illustrates reading of a read image that is larger in size than a BM image from the image sensor **32**. FIG. **15**(B) illustrates a rotation of the read image and a cutout that are performed by the processing section **72**.

As described with reference to FIGS. **6** and **11**, it is assumed that, when the vehicle **10** is on a flat road surface, a reading control is performed by the controller **71** such that (a pixel signal of a pixel of) the rectangular region R**101** having the same size as a BM image that is a read image, is read from a captured image captured by the image sensor **32** (from the light-receiving surface of the image sensor **32**).

For example, when the vehicle **10** is on an uneven road surface and is inclined in the pitch direction and in the roll direction, the controller **71** controls reading performed by the image sensor **32** such that a reading position used to specify a region R**121** is calculated according to inclination information and a pixel signal of the calculated reading position is read, the region R**121** being larger in size than the region R**111** by the number of pixels corresponding to an angle of the inclination of the vehicle **10** in the roll direction, the region R**121** being upwardly or downwardly offset from the region R**111** by the number of pixels corresponding to an angle of the inclination of the vehicle **10** in the pitch direction.

Further, for example, a rotation angle used to rotate the region R**121** corresponding to a read image output by the image sensor **32** is calculated by the controller **71** according to inclination information, such that the horizontal line appearing in the region R**121** corresponding to the read image, appears to extend horizontally, and the calculated rotation angle is supplied by the controller **71** to the processing section **72**.

The rectangular region R**121** is read by the image sensor **32** as a read image in accordance with the reading control performed by the controller **71**, and is supplied by the image sensor **32** to the processing section **72**.

The region R**121** that is the read image from the image sensor **32** is rotated by the processing section **72** by the rotation angle from the controller **71**. Then, a region R**123** that has the same size as a BM image and of which the angle of rotation is 0 degrees, is cut out of a region R**122** by the processing section **72** as the BM image, the region R**122** being obtained by rotating the region R**121**.

In FIG. **15**, the vehicle **10** is inclined to the back, that is, in the pitch direction, and is inclined to the right, that is, in the roll direction. Thus, the region R**121** that is larger in size than the region R**101** and is upwardly offset from the region R**101** is read from the image sensor **32** as a read image. Further, the vehicle **10** is inclined to the right, that is, in the roll direction, and thus the horizontal line appearing in the region R**121** that is the read image is inclined diagonally upward right. Thus, the region R**121** that is the read image is rotated clockwise by the processing section **72** such that the horizontal line inclined diagonally upward right extends horizontally. Further, the region R**123** that is a BM image is cut out of the region R**122** by the processing section **72**, the region R**122** being obtained by rotating the region R**121**.

Accordingly, it is possible to easily obtain, as a BM image, an image suitable for the operation of the vehicle **10**. In other words, it is possible to easily obtain a BM image exhibiting image representation similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, regardless of the inclination of the vehicle in the pitch direction and the inclination of the vehicle **10** in the roll

direction. This makes it possible to display an image in which the horizontal line extends horizontally regardless of the inclination of the vehicle Thus, there is no difference in display image (no difference in a position of the horizontal line) due to a temporary difference in inclination from a rear vehicle. This enables a driver to grasp a state behind the vehicle without worrying about a difference in display image that is caused during driving (a difference in a position of the horizontal line).

Note that, in the third example of the configuration of the viewing system, the detector **42** can detect the inclinations of the vehicle **10** in the pitch direction and in the roll direction from, for example, suspension information.

Further, the detector **42** can recognize the unevenness of a road surface ahead of the vehicle **10** from, for example, a front camera image, and, according to a result of recognizing the unevenness, the detector **42** can estimate to detect the inclinations of the vehicle **10** in the pitch direction and in the roll direction when the vehicle **10** travels on the road surface having the recognized unevenness.

<Display Processing>

FIG. **16** is a flowchart describing an example of display processing of displaying a BM image that is performed in the third example of the configuration of the viewing system of FIG. **14**.

In Step S**31**, the acquisition section **41** acquires suspension information or a front camera image as vehicle information, and supplies the vehicle information to the detector **42**. Then, the process moves on to Step S**32**.

In Step S**32**, the detector **42** detects, using the vehicle information from the acquisition section **41**, a state of the unevenness of a road surface on which the vehicle **10** is situated. Further, the detector **42** detects (calculates), using the vehicle information from the acquisition section **41**, inclination information that indicates the inclination of the vehicle **10** due to the unevenness of a road surface (the inclinations to the front and to the back, that is, in the pitch direction, and the inclinations to the left and to the right, that is, in the roll direction), and supplies the detected inclination information to the controller **71**. Then, the process moves on to Step S**33** from Step S**32**.

In Step S**33**, the controller **71** calculates, according to the inclination information from the detector **42**, a reading-start position for and the reading size of a read image from the image sensor **32**, and supplies the reading-start position and the reading size to the image sensor **32** as a reading position. Further, the controller **71** calculates, according to the inclination information from the detector **42**, a rotation angle used to rotate the read image, and supplies the calculated rotation angle to the processing section **72**. Then, the process moves on to Step S**34** from Step S**33**.

In Step S**34**, the image sensor **32** reads a pixel signal of a pixel of the reading position supplied by the controller **71**, and acquires a read image that exhibits a pixel value corresponding to the pixel signal to output the acquired read image. The read image output by the image sensor **32** is supplied to the processing section **72**, and the process moves on to Step S**35** from Step S**34**.

In Step S**35**, the processing section **72** rotates the read image from the image sensor **32** by the rotation angle from the controller **71**. Further, the processing section **72** cuts a BM image out of the rotated read image, and supplies the BM image to the output section **33**. Then, the process moves on to Step S**36** from Step S**35**.

In Step S**36**, the output section **33** transmits, to the BM display section **21**, the BM image from the processing section **72**, and causes the BM image to be displayed on the BM display section **21**. This results in the BM image being displayed on the BM display section **21**, and the displaying processing is terminated.

As described above, in the third example of the configuration of the viewing system, inclination information is detected that indicates the inclinations to the front and to the back, that is, in the pitch direction as well as the inclinations to the left and to the right, that is, in the roll direction, and reading of a read image from the image sensor **32** is controlled according to the inclination information. Further, in the third example of the configuration of the viewing system, a rotation of the read image is controlled according to the inclination information, and a BM image is cut out of the read image after the rotation. Thus, the third example of the configuration of the viewing system makes it possible to easily provide an image suitable for the operation of the vehicle **10**. In other words, a BM image having an amount of information similar to that of a BM image obtained when the vehicle **10** is on a flat road surface, can be easily provided when the vehicle **10** is on an uneven road surface.

Further, in the third example of the configuration of the viewing system, a read image having a smallest size such that a BM image can be cut out of the read image after rotation, is read from the image sensor **32** in the reading control, as in the second example of the configuration of the viewing system. This makes it possible to reduce the possibility of reducing the frame rate of the BM image.

The suspension information and the front camera image have been described as examples of the vehicle information in the third configuration example. However, the gyroscopic information; the GPS information and the 3D map; or the like may be used as the vehicle information, as in the first or second configuration example described above. Then, the inclination of the vehicle may be detected using the gyroscopic information; the GPS information and the 3D map; or the like.

Note that the present technology is applicable not only to the case in which the vehicle **10** is inclined according to a state of a road surface on which the vehicle **10** is situated, but also to the case in which the vehicle **10** is inclined according to, for example, an object loaded on the vehicle **10** or a state of an occupant of the vehicle **10**. In other words, the present technology is applicable regardless of a cause for the inclination of the vehicle **10**.

Fourth Example of Configuration of Viewing System

FIG. **17** is a block diagram illustrating a fourth example of the configuration of the viewing system included in the vehicle **10**.

The viewing system includes the camera unit **11**, the BM display section **21**, and the RV display section **22** described with reference to FIGS. **1** and **2**.

The camera unit **11** includes the optical system **31**, the image sensor **32**, a data amount adjuster **133**, an output section **134**, an acquisition section **135**, and a controller

The optical system **31** includes optical components such as a condenser and a diaphragm, and collects light entering the optical system **31** onto the image sensor **32**.

The image sensor **32** receives light from the optical system **31** and performs photoelectric conversion to capture a captured image. Then, in accordance with control performed by the controller **136**, the image sensor **32** extracts a BM image and an RV image from the captured image to output the extracted images. The BM image and the RV

image that are output by the image sensor **32** are supplied to the data amount adjuster **133**.

In accordance with control performed by the controller **136**, the data amount adjuster **133** adjusts data amounts of the BM image and the RV image that are output by the image sensor **32**, and supplies, to the output section **134**, the BM image and the RV image of which the respective data amounts have been adjusted.

The output section **134** is an output interface (IF) that transmits, to the outside of the camera unit **11**, the BM image and the RV image from the data amount adjuster **133**. The output section **134** transmits the BM image to the BM display section **21**, and transmits the RV image to the RV display section **22**. The BM image from the output section **134** is displayed on the BM display section **21** in accordance with the specification of the BM display section **21**, and the RV image from the output section **134** is displayed on the RV display section **22** in accordance with the specification of the RV display section **22**. The output section **134** is capable of performing a format conversion and other image processing on the BM image and the RV image as necessary.

The acquisition section **135** acquires vehicle information from the vehicle **10**, and supplies the acquired vehicle information to the controller **136**.

Examples of the vehicle information acquired by the acquisition section **135** include traveling information, the specifications of the BM display section **21** and the RV display section **22**, positions of the line of sight and the head of a driver of the vehicle **10**, and gyroscopic information.

The traveling information is information that indicates a traveling state of the vehicle **10**, and specifically indicates a vehicle speed and a traveling direction (forward or backward). For example, it is possible to acquire the vehicle speed from output of a speed sensor when the vehicle **10** includes the speed sensor. For example, it is possible to acquire the traveling direction from a state of the transmission.

For example, the specifications of the BM display section **21** and the RV display section **22** are the resolution of the BM display section **21** and the resolution of the RV display section **22**, and can be acquired from the BM display section **21** and the RV display section **22**.

The positions of the line of sight and the head of a driver of the vehicle **10** are obtained from an image captured by the in-vehicle camera **23**.

The gyroscopic information is information that indicates a pose of the vehicle **10** (/ an angle of the inclination of the vehicle). It is possible to obtain the gyroscopic information from output of a gyroscope when the vehicle **10** includes the gyroscope. The use of the gyroscopic information makes it possible to recognize whether the vehicle **10** is on a hill.

The controller **136** controls the image sensor **32** and the data amount adjuster **133** according to the vehicle information supplied by the acquisition section **135**.

In other words, for example, the controller performs a reading control similar to the reading control performed by the controller **43**, according to the vehicle information. Accordingly, the controller **136** performs an extraction control for controlling extraction of a BM image and an RV image from a captured image captured by the image sensor **32**. Examples of ranges of reading the BM image and the RV image include the ranges illustrated in FIG. **4**. Further, according to the vehicle information, the controller **136** performs an adjustment control for controlling adjustment of data amounts of the BM image and the RV image that is performed by the data amount adjuster **133**.

Thus, it can be said that the image sensor extracts a BM image and an RV image from a captured image according to vehicle information, and the data amount adjuster **133** adjusts data amounts of the BM image and the RV image according to the vehicle information.

<Image That Can be Output by Image Sensor **32**>

FIG. **18** illustrates an example of an image that can be output by the image sensor **32**.

Here, a highest-resolution captured image that can be output by the image sensor **32** is referred to as a highest-resolution image. It is assumed that, for example, the image sensor **32** has the ability to output a highest-resolution image of a resolution (the number of pixels) Rmax at (a frame rate of) 60 fps (frame per second) or more.

Here, it is assumed that a resolution RBM for a highest-resolution BM image (a BM image of a largest number of pixels) that is extracted from the highest-resolution image is equal to or less than ½ of the resolution Rmax for the highest-resolution image. It is also assumed that a resolution RRV for a highest-resolution RV image that is extracted from the highest-resolution image is equal to or less than the resolution RBM for the BM image.

In the present embodiment, it is assumed that, for example, a sum RBM+RRV of the resolution RBM for a BM image and the resolution RRV for an RV image is equal to or less than ½ of the resolution Rmax for the highest-resolution image. In this case, the use of the image sensor capable of outputting a highest-resolution image of the resolution Rmax at 60 fps (or more) makes it possible to output both the BM image of the resolution RBM and the RV image of the resolution RRV at 120 fps, the BM image and the RV image being obtained by partially reading the high-resolution image.

Example of Vehicle Transmission Bandwidth That Can be Used for Data Transmission in Vehicle **10**

FIG. **19** is a diagram describing an example of a vehicle transmission bandwidth that can be used for data transmission in the vehicle **10**.

In other words, FIG. **19** illustrates examples of a BM image and an RV image that can be output by the camera unit **11** without data amounts being adjusted by the data amount adjuster **133**.

For example, the camera unit **11** can output, as a BM image, a color image of the resolution RBM in a YUV 4:2:2 format in which the number of bits per pixel is eight (with respect to each of the brightness and a difference in color). Further, for example, the camera unit **11** can output, as an RV image, a color image of the resolution RRV in the YUV 4:2:2 format in which the number of bits per pixel is eight.

The BM image of the resolution RBM in the YUV 4:2:2 format in which the number of bits per pixel is eight is referred to as a highest-quality BM image, and the RV image of the resolution RRV in the YUV 4:2:2 format in which the number of bits per pixel is eight is referred to as a highest-quality RV image.

In the present embodiment, it is assumed that the vehicle transmission bandwidth, which is a bandwidth in which data is transmitted from the camera unit **11**, is a transmission bandwidth in which, for example, two screens of a highest-quality BM image at 60 fps can be transmitted (in real time). In the present embodiment, the vehicle transmission bandwidth in which two screens of a highest-quality BM image at 60 fps can be transmitted, makes it possible to transmit, for example, two screens of a highest-quality RV image at 60 fps, since RBM RRV. Further, the vehicle transmission

bandwidth makes it possible to transmit, for example, two screens in total that are a single screen of the highest-quality BM image at fps, and a single screen of the highest-quality RV image at 60 fps.

As described with reference to FIGS. **18** and **19**, the camera unit **11** is capable of outputting both a highest-quality BM image and a highest-quality RV image at up to 120 fps.

However, in the present embodiment, the vehicle transmission bandwidth only makes it possible to transmit two screens of a highest-quality BM image (or RV image) at 60 fps.

The increase in vehicle transmission bandwidth makes it possible to transmit both a highest-quality BM image and a highest-quality RV image at 120 fps that can be output by the camera unit **11**. However, the increase in vehicle transmission bandwidth results in increasing the costs for the viewing system.

In the present technology, the camera unit appropriately adjusts data amounts of a BM image and an RV image to transmit the BM image and the RV image in the vehicle transmission bandwidth, in order to suppress an increase in the costs for the viewing system.

<Control of Adjustment of Data Amounts of BM Image and RV Image When Two Screens of Highest-Quality BM Image at 60 fps Can be Transmitted in Vehicle Transmission Bandwidth>

FIG. **20** is a diagram describing a first example of a control of adjustment of data amounts of a BM image and an RV image, the control being performed by the controller **136**.

A of FIG. **20** illustrates the adjustment control performed when the vehicle **10** is traveling forward, or is traveling backward at a high speed that is a speed equal to or greater than a first threshold for speed.

In this case, the controller **136** performs an adjustment control that is a control of the data amount adjuster **133**, such that a BM image of the resolution RBM at fps is output and output of an RV image is restricted. In accordance with the adjustment control performed by the controller **136**, the data amount adjuster **133** adjusts data amounts of a BM image and an RV image from the image sensor to output the BM image of the resolution RBM at 120 fps and to restrict output of the RV image.

Thus, in this case, the BM image of the resolution RBM at 120 fps is output from the camera unit **11**, and the RV image is not output from the camera unit **11**. Consequently, the BM image of the resolution RBM at 120 fps is displayed on the BM display section **21**, and the RV image is not displayed on the RV display section **22**.

As described above, when the vehicle **10** is traveling forward, or is traveling backward at the high speed, a driver can confirm a region situated further rearward than a region just behind the rear of the vehicle **10**, using a BM image of the resolution RBM at 120 fps, that is, a high-resolution BM image at a high frame rate.

Note that, when the vehicle **10** is traveling forward, or is traveling backward at the high speed, an RV image that includes an image of the region just behind the rear of the vehicle **10** is not displayed.

Further, a BM image of the resolution RBM at fps that is output by the camera unit **11** can be transmitted in the vehicle transmission bandwidth in which two screens of a highest-quality BM image (of the resolution RBM) at 60 fps can be transmitted.

Here, examples of a data amount adjusting method for adjusting a data amount of an image that is performed by the data amount adjuster **133** include a method for reducing resolution (the number of pixels), a method for reducing gradation (the number of bits per pixel), a method for reducing a frame rate, and a compression method using a specified compression-encoding approach, in addition to the method for restricting output of an image (not outputting an image) as described above.

In addition to being performed by the data amount adjuster **133**, a restriction of output of an image, a reduction in resolution, a reduction in gradation, and a reduction in frame rate from among the data amount adjusting methods can be performed by the image sensor **32** by the controller **136** performing control such as a control of extraction performed by the image sensor **32**.

In other words, the restriction of output of an image such as a restriction of output of an RV image can be performed by the controller **136** controlling reading of data from the image sensor **32** and not reading a pixel signal corresponding to the RV image from the pixel **51** (FIG. **7**), such that extraction of an RV image from a captured image is restricted. When the vehicle **10** is traveling forward, or is traveling backward at the high speed, the controller **136** can control, according to vehicle information, extraction performed by the image sensor **32** such that extraction of an RV image from a captured image is restricted. Of course, output of an RV image may be restricted by the data amount adjuster **133**, not by the image sensor **32**.

The resolution of an image can be reduced by, for example, the controller **136** controlling the image sensor **32** such that the number of pixels **51** from which a pixel signal is read is reduced, or such that binning for adding pixel signals of a plurality of pixels **51** is performed by performing, for example, a so-called source follower (SF) addition or floating diffusion (FD) addition.

The gradation can be reduced by, for example, the controller **136** controlling the image sensor **32** such that the number of bits necessary for AD conversion performed by the AD converter **55** (FIG. **7**) is reduced.

The frame rate can be reduced by, for example, the controller **136** controlling the image sensor **32** such that a rate at which a pixel signal is read from the pixel **51**, or a rate at which AD conversion is performed by the AD converter **55** is reduced.

B of FIG. **20** illustrates the adjustment control performed when the vehicle **10** is traveling backward at a medium speed that is a speed that is less than the first threshold and is equal to or greater than a second threshold less than the first threshold.

In this case, the controller **136** performs an adjustment control that is a control of the data amount adjuster **133** such that a BM image of a resolution RBMM at fps is output and an RV image of a resolution RRVM at fps is output, the resolution RBMM being less than the resolution RBM, the resolution RRVM being less than the resolution RRV. In accordance with the adjustment control performed by the controller **136**, the data amount adjuster adjusts data amounts of a BM image and an RV image from the image sensor **32** to output the BM image of the resolution RBMM at 120 fps and to output the RV image of the resolution RRVM at 30 fps.

Thus, in this case, the BM image of the resolution RBMM at 120 fps and the RV image of the resolution RRVM at 30 fps are output by the camera unit **11**. Consequently, the BM image of the resolution RBMM at 120 fps is displayed on the BM display section **21**, and the RV image of the resolution RRVM at 30 fps is displayed on the RV display section **22**.

As described above, when the vehicle **10** is traveling backward at the medium speed, a driver can confirm a region situated further rearward than a region just behind the rear of the vehicle **10**, using a BM image of the resolution RBMM at 120 fps, that is, a medium-resolution BM image at the high frame rate. Further, the driver can confirm the region just behind the rear of the vehicle **10**, using an RV image of the resolution RRVM at 30 fps, that is, a medium-resolution RV image at a low frame rate.

Note that it is assumed that a transmission bandwidth necessary to transmit an RV image of the resolution RRVM at 30 fps is equal to or less than a transmission bandwidth for a difference between a maximum transmission rate (here, a transmission rate necessary to transmit a BM image of the resolution RBM at 120 fps without compressing the BM image) and a transmission rate (a first transmission rate) necessary to transmit the resolution RBMM at 120 fps. In this case, both a BM image of the resolution RBMM at 120 fps and an RV image of the resolution RRVM at 30 fps that are output by the camera unit **11** can be transmitted in the vehicle transmission bandwidth in which two screens of a highest-quality BM image at 60 fps can be transmitted.

Here, when the transmission bandwidth necessary to transmit an RV image of the resolution RRVM at fps is not equal to or less than the transmission bandwidth for the difference between the maximum transmission rate and the first transmission rate, one of the BM image and the RV image or both of them can be compressed (compression-encoded) by the data amount adjuster **133** such that the transmission bandwidth necessary to transmit the RV image of the resolution RRVM at 30 fps is equal to or less than the transmission bandwidth for the difference between the maximum transmission rate and the first transmission rate (such that the RV image of the resolution RRVM can be transmitted). For example, with respect to a BM image of the resolution RRVM at 120 fps, a portion of or all of the BM image is compressed (compression-encoded). This results in being able to reduce a data amount of the BM image. With respect to an RV image of the resolution RRVM at 30 fps, the RV image is compression-encoded in a state of remaining a color image, or is converted into a black-and-white image to be compression-encoded. This results in being able to reduce a data amount of the RV image.

C of FIG. **20** illustrates the adjustment control performed when the vehicle **10** is traveling backward at a low speed that is a speed that is less than the second threshold less than the first threshold.

In this case, the controller **136** performs an adjustment control that is a control of the data amount adjuster **133** such that a BM image of the resolution RBM at fps is output and an RV image of the resolution RRV at fps is output. In accordance with the adjustment control performed by the controller **136**, the data amount adjuster adjusts data amounts of a BM image and an RV image from the image sensor **32** to output the BM image of the resolution RBM at 60 fps and to output the RV image of the resolution RRV at 60 fps.

Thus, in this case, the BM image of the resolution RBM at 60 fps and the RV image of the resolution RRV at 60 fps are output by the camera unit **11**. Consequently, the BM image of the resolution RBM at 60 fps is displayed on the BM display section **21**, and the RV image of the resolution RRV at 60 fps is displayed on the RV display section **22**.

As described above, when the vehicle **10** is traveling backward at the low speed, a driver can confirm a region situated further rearward than a region just behind the rear of the vehicle **10**, using a BM image of the resolution RBM at 60 fps, that is, a high-resolution BM image at a medium frame rate. Further, the driver can confirm the region just behind the rear of the vehicle **10**, using an RV image of the resolution RRV at 60 fps, that is, a high-resolution RV image at the medium frame rate.

The case in which the vehicle **10** is traveling backward at the low speed is, for example, a case in which a driver is about to park the vehicle **10**, and it is important to confirm a region just behind the rear of the vehicle **10** that is a blind spot as viewed from the driver. Thus, when the vehicle **10** is traveling backward at the low speed, an RV image is displayed at a higher resolution and at a higher frame rate, compared to when the vehicle **10** is traveling backward at the high speed or the medium speed. This makes it possible to easily confirm a region of a blind spot and to easily control the vehicle according to a state of the blind spot.

Note that both a BM image of the resolution RBM at 60 fps and an RV image of the resolution RRV at 60 fps that are output by the camera unit **11** can be transmitted in the vehicle transmission bandwidth in which two screens of a highest-quality BM image at 60 fps can be transmitted.

<Control of Adjustment of Data Amounts of BM Image and RV Image When Single Screen of Highest-Quality BM Image at 60 fps Can be Transmitted in Vehicle Transmission Bandwidth>

FIG. **21** is a diagram describing a second example of the control of adjustment of data amounts of a BM image and an RV image, the control being performed by the controller **136**.

Here, in the second example of the control of adjustment of data amounts of a BM image and an RV image, it is assumed that the vehicle transmission bandwidth is a transmission bandwidth in which, for example, a single screen of a highest-quality BM image (of the resolution RBM) at 60 fps (or more) can be transmitted.

A of FIG. **21** illustrates the adjustment control performed when the vehicle **10** is traveling forward, or is traveling backward at the high speed that is a speed equal to or greater than the first threshold for speed.

In this case, the controller **136** performs an adjustment control that is a control of the data amount adjuster **133**, such that a BM image of the resolution RBM at fps (or more) is output and output of an RV image is restricted. In accordance with the adjustment control performed by the controller **136**, the data amount adjuster adjusts data amounts of a BM image and an RV image from the image sensor **32** to output the BM image of the resolution RBM at 60 fps and to restrict output of the RV image.

Thus, in this case, the BM image of the resolution RBM at 60 fps is output from the camera unit **11**, and the RV image is not output from the camera unit **11**. Consequently, the BM image of the resolution RBM at 60 fps is displayed on the BM display section **21**, and the RV image is not displayed on the RV display section **22**.

As described above, when the vehicle **10** is traveling forward, or is traveling backward at the high speed, a driver can confirm a region situated further rearward than a region just behind the rear of the vehicle **10**, using a BM image of the resolution RBM at 60 fps, that is, a high-resolution BM image at the medium frame rate.

Note that, when the vehicle **10** is traveling forward, or is traveling backward at the high speed, an RV image that includes an image of the region just behind the rear of the vehicle **10** is not displayed, as described with reference to A of FIG. **20**.

Further, a BM image of the resolution RBM at 60 fps that is output by the camera unit **11** can be transmitted in the

vehicle transmission bandwidth in which a single screen of a highest-quality BM image (of the resolution RBM) at 60 fps can be transmitted.

B of FIG. **21** illustrates the adjustment control performed when the vehicle **10** is traveling backward at the medium speed that is a speed that is less than the first threshold and is equal to or greater than the second threshold less than the first threshold.

In this case, the controller **136** performs an adjustment control that is a control of the data amount adjuster **133** such that a BM image of the resolution RBMM at fps is output and an RV image of the resolution RRVM at fps is output, the resolution RBMM being less than the resolution RBM, the resolution RRVM being less than the resolution RRV. In accordance with the adjustment control performed by the controller **136**, the data amount adjuster adjusts data amounts of a BM image and an RV image from the image sensor **32** to output the BM image of the resolution RBMM at 60 fps and to output the RV image of the resolution RRVM at 30 fps.

Thus, in this case, the BM image of the resolution RBMM at 60 fps and the RV image of the resolution RRVM at 30 fps are output by the camera unit **11**. Consequently, the BM image of the resolution RBMM at 60 fps is displayed on the BM display section **21**, and the RV image of the resolution RRVM at 30 fps is displayed on the RV display section **22**.

As described above, when the vehicle **10** is traveling backward at the medium speed, a driver can confirm a region situated further rearward than a region just behind the rear of the vehicle **10**, using a BM image of the resolution RBMM at 60 fps, that is, a medium-resolution BM image at the medium frame rate. Further, the driver can confirm the region just behind the rear of the vehicle **10**, using an RV image of the resolution RRVM at 30 fps, that is, a medium-resolution RV image at the low frame rate.

Note that, when a transmission bandwidth (hereinafter also referred to as a necessary transmission bandwidth) necessary to transmit both a BM image of the resolution RBMM at 60 fps and an RV image of the resolution RRVM at 30 fps that are output by the camera unit **11**, is not within the vehicle transmission bandwidth in which a single screen of a highest-quality BM image at 60 fps can be transmitted, the BM image may be compressed at a first compression rate for medium speed, and the RV image may be compressed in a state of remaining a color image at a second compression rate for medium speed that provides a higher compression than the first compression rate for medium speed, or the RV image may be converted into a black-and-white image to be compressed at the second compression rate for medium speed, such that the necessary transmission bandwidth is within the vehicle transmission bandwidth.

C of FIG. **21** illustrates the adjustment control performed when the vehicle **10** is traveling backward at the low speed that is a speed that is less than the second threshold less than the first threshold.

In this case, the controller **136** performs an adjustment control that is a control of the data amount adjuster **133** such that a BM image of a resolution RBML at fps is output and an RV image of the resolution RRVM at fps is output, the resolution RBML being less than the resolution RBMM. In accordance with the adjustment control performed by the controller **136**, the data amount adjuster adjusts data amounts of a BM image and an RV image from the image sensor **32** to output the BM image of the resolution RBML at 60 fps and to output the RV image of the resolution RRVM at 30 fps.

Thus, in this case, the BM image of the resolution RBML at 60 fps and the RV image of the resolution RRV at 30 fps are output by the camera unit **11**. Consequently, the BM image of the resolution RBML at 60 fps is displayed on the BM display section **21**, and the RV image of the resolution RRVM at 30 fps is displayed on the RV display section **22**.

As described above, when the vehicle **10** is traveling backward at the low speed, a driver can confirm a region situated further rearward than a region just behind the rear of the vehicle **10**, using a BM image of the resolution RBML at 60 fps, that is, a low-resolution BM image at the medium frame rate. Further, the driver can confirm the region just behind the rear of the vehicle **10**, using an RV image of the resolution RRVM at 30 fps, that is, a medium-resolution RV image at the low frame rate.

Note that, when the necessary transmission bandwidth necessary to transmit both a BM image of the resolution RBML at 60 fps and an RV image of the resolution RRVM at 30 fps that are output by the camera unit **11**, is not within the vehicle transmission bandwidth in which a single screen of a highest-quality BM image at 60 fps can be transmitted, the BM image may be compressed at a first compression rate for low speed, and the RV image may be compressed (in a state of remaining a color image) at a second compression rate for low speed that provides a higher compression than the first compression rate for low speed, such that the necessary transmission bandwidth is within the vehicle transmission bandwidth.

Here, a rate that provides a higher compression than the first compression rate for medium speed can be adopted as the first compression rate for low speed. The same compression rate can be adopted as the second compression rate for medium speed and the second compression rate for low speed. In this case, the following is the relationship among the first and second compression rates for low speed, and the first and second compression rates for medium speed: the second compression rate for low speed=the second compression rate for medium speed>the first compression rate for low speed>the first compression rate for medium speed. However, here, it is assumed that a compression rate exhibiting a larger value provides a higher compression. The following is the relationship among data amounts respectively obtained by performing compression at the first compression rate for low speed, by performing compression at the second compression rate for low speed, by performing compression at the first compression rate for medium speed, and by performing compression at the second compression rate for medium speed: the data amount obtained by the compression at the second compression rate for low speed=the data amount obtained by the compression at the second compression rate for medium speed<the data amount obtained by the compression at the first compression rate for low speed<the data amount obtained by the compression at the first compression for medium speed.

The adjustment control for adjusting data amounts of a BM image and an RV image according to the vehicle speed and the traveling direction (forward or backward) of the vehicle **10** has been described above. The adjustment control method is not limited to the methods described with reference to FIGS. **20** and **21**. In other words, the adjustment control method may be set as appropriate according to, for example, the vehicle transmission bandwidth, the ability of the image sensor **32**, and the specifications of the BM display section **21** and the RV display section **22**. The data amounts are respectively related to the quality of a displayed BM image and a displayed RV image. Thus, it can be said that the quality of a BM image and the quality of an RV

image are changed according to the vehicle speed and the traveling direction (forward or backward) of the vehicle **10**.

Further, in the adjustment control, the resolution of the BM image and the resolution of the RV image can be reduced by reducing the number of pixels included in the BM image and the RV image, or by (irreversibly) compressing the BM image and the RV image without changing the number of pixels.

When the resolution of a BM image and the resolution of an RV image are reduced by compressing the BM image and the RV image, it is possible to adopt, as compression rates at which the BM image and the RV image are compressed, compression rates such that a BM image and an RV image that are obtained by performing compression and decompression and from which a portion of frequency components such as a high frequency component has been lost, each have a substantial resolution (a highest frequency component) that is equivalent to the resolution (the number of pixels) described with reference to FIG. **20** or **21**.

<Display Processing>

FIG. **22** is a flowchart describing an example of display processing of displaying a BM image and an RV image that is performed in the viewing system of FIG. **17**.

In Step S**111**, the image sensor **32** captures a captured image, and the process moves on to Step S**112**.

In Step S**112**, the acquisition section **135** acquires vehicle information from the vehicle **10**, and supplies the vehicle information to the controller **136**. Then, the process moves on to Step S**113**.

In Step S**113**, the controller **136** controls extraction performed by the image sensor **32** according to the vehicle information from the acquisition section **135**. The image sensor **32** extracts a BM image and an RV image from the captured image in accordance with the extraction control performed by the controller **136**. Then, the image sensor **32** supplies the BM image and the RV image to the data amount adjuster **133**, and the process moves on to Step S**114** from Step S**113**.

In Step S**114**, the controller **136** controls adjustment performed by the data amount adjuster **133** according to the vehicle information from the acquisition section **135**. The data amount adjuster **133** adjusts data amounts of the BM image and the RV image from the image sensor **32** in accordance with the adjustment control performed by the controller **136**. Then, the data amount adjuster **133** supplies, to the output section **134**, the BM image and the RV image of which the respective data amounts have been adjusted, and the process moves on to Step S**115** from Step S**114**.

In Step S**115**, the output section **134** outputs, to the outside of the camera unit **11**, the BM image and the RV image that are supplied from the data amount adjuster and of which the respective data amounts have been adjusted, transmits the BM image to the BM display section **21**, and transmits the RV image to the RV display section **22**. Then, the process moves on to Step S**116**.

In Step S**116**, the BM display section **21** displays thereon the BM image from the output section **134** in accordance with the specification of the BM display section **21**, and the RV display section **22** displays thereon the RV image from the output section **134** in accordance with the specification of the RV display section **22**.

Fifth Example of Configuration of Viewing System

FIG. **23** is a block diagram illustrating a fifth example of the configuration of the viewing system included in the vehicle **10**.

Note that, in the figure, a portion corresponding to that in FIG. **17** is denoted by the same reference numeral as FIG. **17**, and a description thereof is omitted below.

In FIG. **23**, the viewing system includes the camera unit **11**, the BM display section **21**, the RV display section **22**, and an extraction section **182**, and the camera unit **11** includes the optical system **31**, the image sensor **32**, the data amount adjuster **133**, the output section **134**, the acquisition section **135**, and a controller **181**.

Thus, the viewing system of FIG. **23** is similar to the viewing system of FIG. **17** in including the camera unit **11**, the BM display section **21**, and the RV display section **22**, and in that the camera unit **11** includes the components from the optical system **31** to the acquisition section **135**.

However, the viewing system of FIG. **23** is different from the viewing system of FIG. **17** in newly including the extraction section **182**, and in that the camera unit **11** includes the controller **181** instead of the controller **136**.

Note that the extraction section **182** may be provided within the camera unit **11**, although the extraction section **182** is provided outside of the camera unit **11** in FIG. **23**.

Vehicle information is supplied by the acquisition section **135** to the controller **181**. Examples of the vehicle information include traveling information, the specifications of the BM display section **21** and the RV display section **22**, and gyroscopic information. However, in this example, the vehicle information supplied by the acquisition section **135** does not include positions of the line of sight and the head of a driver. Note that the positions of the line of sight and the head of the driver of the vehicle **10** are input to the extraction section **182** as a portion of the vehicle information.

As in the case of the controller **136**, the controller **181** controls extraction performed by the image sensor **32** and adjustment performed by the data amount adjuster **133**, according to the vehicle information supplied by the acquisition section **135**.

However, in the extraction control, the controller **181** causes a region larger in size than the region R**11** to be extracted as a BM image instead of controlling (the position of) the region R**11** extracted as the BM image, according to one of the positions of the line of sight and the head of the driver, or according to both of them.

Thus, the BM image output by the output section **134** in FIG. **23** is larger in size than the BM image output by the output section **134** in FIGS. **17** and **12**.

In FIG. **23**, the BM image larger in size than the region R**11** output by the output section **134** is supplied to the extraction section **182**.

The positions of the line of sight and the head of the driver from among the vehicle information are supplied to the extraction section **182**, in addition to the BM image larger in size than the region R**11** being supplied by the output section **134** to the extraction section **182**.

According to one of the positions of the line of sight and the head of the driver, or according to both of them, the extraction section **182** extracts, as a final BM image to be displayed on the BM display section **21**, a region that is a portion of the BM image larger in size than the region R**11** from the output section **134**, that is, a region having the same size as the region R**11**, and the extraction section **182** supplies the BM image to the BM display section **21**.

<Control of Extraction of BM Image and RV Image from Captured Image>

FIG. **24** is a diagram describing an example of a control of extraction of a BM image and an RV image from a captured image, the control being performed by the controller **181**.

As in the case of FIG. **4**, FIG. **24** illustrates an image circle of the optical system **31** and a captured image captured by the image sensor **32** (the light-receiving surface of the image sensor **32**).

In the extraction control, the controller controls reading of data from the image sensor **32** such that the region R**12** is extracted as an RV image, as in the case of the controller **136**.

Further, 0262 tin the extraction control, the controller **181** controls reading of data from the image sensor **32** such that not the region R**11** but a region R**31** that is larger in size than the region R**11** is extracted from the captured image as a BM image.

The region R**31** is a region that includes a largest range that a driver can see using an interior rearview mirror by moving his/her line of sight or his/her head, if the interior rearview mirror is installed in the vehicle **10**. The region R**11** is a variable region of which the position is changed according to positions of the line of sight and the head of the driver, whereas the region R**31** is a fixed region.

A region that is situated at a position depending on one of the positions of the line of sight and the head of the driver or depending on both of them, and has the same size as the region R**11**, is extracted by the extraction section **182** from the region R**31** described above as a final BM image to be displayed on the BM display section **21**. In other words, the region R**11** to be observed by the driver using an interior rearview mirror if the interior rearview mirror is installed in the vehicle **10**, is extracted by the extraction section **182** from the region R**31** as a BM image.

<Display Processing>

FIG. **25** is a flowchart describing an example of display processing of displaying a BM image and an RV image that is performed in the viewing system of FIG. **23**.

In Step S**121**, the image sensor **32** captures a captured image, and the process moves on to Step S**122**.

In Step S**122**, the acquisition section **135** acquires vehicle information from the vehicle **10**, and supplies the vehicle information to the controller **136**. Then, the process moves on to Step S**123**.

In Step S**123**, the controller **136** controls extraction performed by the image sensor **32**. As described with reference to FIG. **24**, in accordance with the extraction control performed by the controller **136**, the image sensor **32** extracts, from the captured image, the regions R**31** and R**12** as a BM image and an RV image, respectively. Then, the image sensor **32** supplies the BM image and the RV image to the data amount adjuster **133**, and the process moves on to Step S**124** from Step S**123**.

In Step S**124**, the controller **136** controls adjustment performed by the data amount adjuster **133** according to the vehicle information from the acquisition section **135**. The data amount adjuster **133** adjusts data amounts of the BM image and the RV image from the image sensor **32** in accordance with the adjustment control performed by the controller **136**. Then, the data amount adjuster **133** supplies, to the output section **134**, the BM image and the RV image of which the respective data amounts have been adjusted, and the process moves on to Step S**125** from Step S**124**.

In Step S**125**, the output section **134** outputs, to the outside of the camera unit **11**, the BM image and the RV image that are supplied from the data amount adjuster **133** and of which the respective data amounts have been adjusted, and the process moves on to Step S**126**. Consequently, in FIG. **23**, the BM image is supplied to the extraction section **182**, and the RV image is transmitted to the RV display section **22**.

In Step S**126**, the extraction section **182** acquires, from the vehicle **10**, positions of the line of sight and the head of a driver that are included in the vehicle information, and the process moves on to Step S**127**.

In Step S**127**, the extraction section **182** extracts, from the BM image from the output section **134**, a region that is situated at a position depending on the positions of the line of sight and the head of the driver and has the same size as the region R**11**, the region being extracted as a final BM image to be displayed on the BM display section **21**. Then, the extraction section **182** transmits the final BM image to the BM display section **21**, and the process moves on to Step S**128** from Step S**127**.

In Step S**128**, the BM display section **21** displays thereon the BM image from the extraction section in accordance with the specification of the BM display section **21**, and the RV display section **22** displays thereon the RV image from the output section **134** in accordance with the specification of the RV display section **22**.

<Description of Computer to Which Present Technology is Applied>

Next, the series of processes described above can be performed using hardware or software. When the series of processes is performed using software, a program included in the software is installed on, for example, a general-purpose computer.

FIG. **26** is a block diagram illustrating an example of a configuration of an embodiment of a computer on which a program used to perform the series of processes described above is installed.

The program can be recorded in advance in a hard disk **905** or a read only memory (ROM) **903** that is a recording medium included in the computer.

Alternatively, the program can be stored (recorded) in a removable recording medium **911** driven by a drive **909**. Such a removable recording medium **911** can be provided as so-called package software. Here, examples of the removable recording medium **911** include a flexible disk, a compact disc read-only memory (CD-ROM), a magneto-optical (MO) disk, a digital versatile disc (DVD), a magnetic disk, and a semiconductor memory.

Note that, in addition to being installed on the computer from the removable recording medium **911** described above, the program can be downloaded to the computer through a communication network or a broadcast network to be installed on the hard disk **905** included in the computer. In other words, for example, the program can be wirelessly transferred to the computer from a download site through a satellite for digital satellite broadcasting, or can be transferred to the computer by wire through a network such as a local area network (LAN) or the Internet.

The computer includes a central processing unit (CPU) **902**, and an input/output interface **910** is connected to the CPU **902** through a bus **901**.

When a command is input by a user operating an input section **907** through the input/output interface **910**, the CPU **902** executes a program stored in the ROM **903** according to the input command. Alternatively, the CPU **902** loads a program stored in the hard disk **905** into a random access memory (RAM) **904** and executes the program.

This results in the CPU **902** performing the processing according to the flowcharts described above or the processing performed on the basis of the configurations of the block diagrams described above. Then, for example, as necessary, the CPU **902** outputs a result of the processing using an output section **906** or transmits the processing result using a

communication section **908** through the input/output interface **910**, and the CPU **902** further records the processing result in the hard disk **905**.

Note that the input section **907** includes, for example, a keyboard, a mouse, and a microphone. Further, the output section **906** includes, for example, a liquid crystal display (LCD) and a speaker.

Here, in the specification, the processes performed by a computer in accordance with a program does not necessarily have to be chronologically performed in the order of the descriptions in the flowcharts. In other words, the processes performed by a computer in accordance with a program include processes performed in parallel or individually (for example, parallel processing or processing performed using an object).

Further, the program may be a program on which processing is performed by a single computer (processor) or may be a program on which distributed-processing is performed by a plurality of computers. Furthermore, the program may be transferred to a remote computer to be executed by the remote computer.

Further, the system as used herein refers to a collection of a plurality of components (such as apparatuses and modules (parts)) and it does not matter whether all of the components are in a single housing. Thus, a plurality of apparatuses accommodated in separate housings and connected to one another via a network, and a single apparatus in which a plurality of modules is accommodated in a single housing are both the system.

Note that the embodiment of the present technology is not limited to the examples described above, and various modifications may be made thereto without departing from the scope of the present technology.

For example, the present technology may also have a configuration of cloud computing in which a single function is shared to be cooperatively processed by a plurality of apparatuses via a network.

Further, the respective steps described using the flowcharts described above may be shared to be performed by a plurality of apparatuses, in addition to being performed by a single apparatus.

Moreover, when a single step includes a plurality of processes, the plurality of processes included in the single step may be shared to be performed by a plurality of apparatuses, in addition to being performed by a single apparatus.

Note that the effects described herein are not limitative but are merely illustrative, and other effects may be provided.

Note that the present technology may take the following configurations.

<1> An image-capturing apparatus, including:
- an image sensor that captures an image displayed on a display section of a vehicle; and
- a controller that controls reading of the image from the image sensor on the basis of vehicle information acquired by the vehicle.

<2> The image-capturing apparatus according to <1>, further including
- a detector that detects inclination information regarding the vehicle using the vehicle information, in which
- according to the inclination information, the controller controls the reading of the image from the image sensor.

<3> The image-capturing apparatus according to <2>, in which
- the detector detects the inclination information indicating forward and rearward inclinations of the vehicle.

<4> The image-capturing apparatus according to <2>, in which
- the detector detects the inclination information indicating leftward and rightward inclinations of the vehicle.

<5> The image-capturing apparatus according to <2>, in which
- the detector detects the inclination information indicating forward and rearward inclinations of the vehicle and leftward and rightward inclinations of the vehicle.

<6> The image-capturing apparatus according to any one of <1> to <5>, in which
- the controller controls a reading position, in the image sensor, from which the image is read.

<7> The image-capturing apparatus according to <6>. In which
- the reading position is specified by a reading-start position and a size of the image read from the image sensor, the reading-start position being a position, in the image sensor, at which the reading of the image from the image sensor is started.

<8> The image-capturing apparatus according to any one of <1> to <7>, in which
- the controller controls the reading of the image from the image sensor such that a proportion of a road surface that appears in the image displayed on the display section is kept in a specified proportion.

<9> The image-capturing apparatus according to any one of <1> to <8>, further including
- a processing section that rotates the image read from the image sensor, and cuts an image to be displayed on the display section out of the rotated image.

<10> The image-capturing apparatus according to <9>, in which
- the controller controls the rotation of the image.

<11> The image-capturing apparatus according to <10>, in which
- the controller
  - calculates a rotation angle used to rotate the image, according to inclination information regarding the vehicle, and
  - controls the rotation of the image such that the image is rotated by the rotation angle.

<12> The image-capturing apparatus according to any one of <1> to <11>, in which
- the vehicle information is at least one of gyroscopic information obtained from a gyroscope of the vehicle, suspension information regarding a suspension of the vehicle, a front camera image obtained from a front camera used to capture an image of a region ahead of the vehicle, or GPS information obtained from the GPS.

<13> The image-capturing apparatus according to any one of <1> to <12>, in which
- the display section is a display section that is an alternative to a Class I mirror.

<14> A control method, including
- controlling reading of an image from an image sensor that captures the image, on the basis of vehicle information acquired by a vehicle, the image being displayed on a display section of the vehicle.

<15> A program that causes a computer to operate as a controller that controls reading of an image from an image sensor that captures the image, on the basis of vehicle information acquired by a vehicle, the image being displayed on a display section of the vehicle.

<16> The control method according to <14>, further including

detecting inclination information regarding the vehicle using the vehicle information, in which

the controlling the reading of the image from the image sensor is performed according to the inclination information.

<17> The program according to <15> further causing the computer to operate as a detector that detects inclination information regarding the vehicle using the vehicle information, in which

the controlling the reading of the image from the image sensor is performed according to the inclination information.

<18> The image-capturing apparatus according to any one of <1> to <13>, in which

the vehicle information includes at least one of speed information regarding the vehicle or gear information regarding the vehicle.

<19> The control method according to <14> or <16>, in which

the vehicle information includes at least one of speed information regarding the vehicle or gear information regarding the vehicle.

<20> The program according to <15> or <17>, in which

the vehicle information includes at least one of speed information regarding the vehicle or gear information regarding the vehicle.

REFERENCE SIGNS LIST

10 vehicle
11 camera unit
21 BM display section
22 RV display section
23 in-vehicle camera
31 optical system
32 image sensor
33 output section
41 acquisition section
42 detector
43 controller
51 pixel array
52 input circuit
53 row selecting circuit
54 column selection circuit
55 AD converter
56 line buffer
57 output circuit
61 pixel
71 controller
72 processing section
133 data amount adjuster
134 output section
135 acquisition section
136 controller
181 controller
182 extraction section
901 bus
902 CPU
903 ROM
904 RAM
905 hard disk
906 output section
907 input section
908 communication section
909 drive
910 input/output interface
911 removable recording medium

The invention claimed is:

1. An image-capturing apparatus, comprising:

an image sensor that captures an image displayed on a display section of a vehicle;

a controller that controls reading of the image from the image sensor, wherein a reading-start position for reading of image data from the sensor is set based on vehicle information acquired by the vehicle; and

a detector that detects inclination information regarding the vehicle using the vehicle information, the inclination information comprising an angle at which the vehicle is determined to be inclined to the front or back;

wherein if the vehicle is determined to be inclined to the front, the controller shifts a region of the image downward according to the angle at which the vehicle is determined to be inclined to the front, and if the vehicle is determined to be inclined to the back, the controller shifts the region of the image upward according to the angle at which the vehicle is determined to be inclined to the back, such that a proportion of a road to the sky in the region of the image remains substantially the same;

wherein the vehicle information includes gear information regarding the vehicle,

wherein the image includes a range corresponding to a back mirror image and a rearview image and

wherein the back mirror image is displayed on a first display and the rearview image is displayed on a second display that is other than the first display.

2. The image-capturing apparatus according to claim **1**, wherein

the detector detects the inclination information indicating leftward and rightward inclinations of the vehicle.

3. The image-capturing apparatus according to claim **1**, wherein

the detector detects the inclination information indicating forward and rearward inclinations of the vehicle and leftward and rightward inclinations of the vehicle.

4. The image-capturing apparatus according to claim **1**, wherein

the controller controls a reading position, in the image sensor, from which the image data is read.

5. The image-capturing apparatus according to claim **4**, wherein

the reading position is specified by the reading-start position and a size of the image read from the image sensor, the reading-start position being a position, in the image sensor, at which the reading of the image from the image sensor is started.

6. The image-capturing apparatus according to claim **1**, wherein

the controller controls the reading of the image data from the image sensor such that a proportion of a road surface that appears in the image displayed on the display section is kept in a specified proportion.

7. The image-capturing apparatus according to claim **1**, further comprising

a processing section that rotates an image corresponding to the image data read from the image sensor, and cuts an image to be displayed on the display section out of the rotated image.

8. The image-capturing apparatus according to claim **7**, wherein the controller controls the rotation of the image.

9. The image-capturing apparatus according to claim **8**, wherein the controller

calculates a rotation angle used to rotate the image, according to inclination information regarding the vehicle, and

controls the rotation of the image such that the image is rotated by the rotation angle.

10. The image-capturing apparatus according to claim **1**, wherein

the vehicle information is at least one of gyroscopic information obtained from a gyroscope of the vehicle, suspension information regarding a suspension of the vehicle, a front camera image obtained from a front camera used to capture an image of a region ahead of the vehicle, or GPS information obtained from the GPS.

11. The image-capturing apparatus according to claim **1**, wherein

the display section is a display section that is an alternative to a Class I mirror.

12. A control method, comprising

controlling reading of an image data from an image sensor that captures the image, wherein a reading-start position for reading of image data from the image sensor is set based on vehicle information acquired by the vehicle; and

detecting inclination information regarding the vehicle using the vehicle information, the inclination information comprising an angle at which the vehicle is determined to be inclined to the front or back;

wherein if the vehicle is determined to be inclined to the front, the controller shifts a region of the image downward according to the angle at which the vehicle is determined to be inclined to the front, and if the vehicle is determined to be inclined to the back, the controller shifts the region of the image upward according to the angle at which the vehicle is determined to be inclined to the back, such that a proportion of a road to the sky in the region of the image remains substantially the same;

wherein the vehicle information includes gear information regarding the vehicle,

wherein the image includes a range corresponding to a back mirror image and a rearview image and

wherein the back mirror image is displayed on a first display and the rearview image is displayed on a second display that is other than the first display.

13. A non-transitory computer readable storage medium having computer readable instructions stored thereon that, when executed by a computer, cause a computer to:

operate as a controller that controls reading of an image data from an image sensor that captures the image, wherein a reading-start position for reading of image data from the image sensor is set based on vehicle information acquired by the vehicle; and

operate as a detector that detects inclination information regarding the vehicle using the vehicle information, the inclination information comprising an angle at which the vehicle is determined to be inclined to the front or back;

wherein if the vehicle is determined to be inclined to the front, the controller shifts a region of the image downward according to the angle at which the vehicle is determined to be inclined to the front, and if the vehicle is determined to be inclined to the back, the controller shifts the region of the image upward according to the angle at which the vehicle is determined to be inclined to the back, such that a proportion of a road to the sky in the region of the image remains substantially the same;

wherein the vehicle information includes gear information regarding the vehicle,

wherein the image includes a range corresponding to a back mirror image and a rearview image and

wherein the back mirror image is displayed on a first display and the rearview image is displayed on a second display that is other than the first display.

14. The image-capturing apparatus according to claim **1**, wherein the vehicle information further includes speed information regarding the vehicle.

15. The control method according to claim **12**, wherein the vehicle information further includes speed information regarding the vehicle.

16. The non-transitory computer readable storage medium according to claim **13**, wherein the vehicle information further includes speed information regarding the vehicle.

* * * * *